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QUANTITY AND QUALITY IN GEOGRAPHY

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I. REASSESSMENTS

TO judge from recent open attacks and internal reassessments, the study of geography is once more facing a crisis, or at least a difficult phase of adjustments and transitions. All life is adjustment and transition, and only people and institutions already dead have no further crises to face. The object of this paper is to present a critique of some recent programmatic statements and tendencies. Any serious discussion of the state of the subject in 1960–61 must at least consider, if it cannot answer, such questions as: Where is the current trend towards increasing quantification taking us? The second part of the paper will be specifically concerned with such questions.

In the upshot—and without descending to the question-begging definition "geography is what geographers do"—the scope and method of any study are what its practitioners make of them, and, provided they avoid the opposing perils of dogmatic *a priori* schematism and the shallower type of empiricism, they will produce data and generalizations which will be accepted as of solid worth by other specialists. Indeed, since in large part our study is not very esoteric, we may have to take time off now and then to discount generalizations fathered upon us by amateurs who have picked up, but not digested, a quantum of glittering and attractive geographical bits and pieces—for an excellent example, Toynbee, Vol. II, *passim*. Or we must explain that we really cannot provide a suit of ready-made clothes which will fit everybody; cannot, that is, provide a set of "geographical laws" for the historian applicable in detail to any time or place, or divide the world into a neat set of formal regions, without gaps or overlaps, which will be useful to political scientists, economists, culture historians, businessmen, botanists, or whomever.[1] What we can do is provide good, honestly woven cloth, and helpful advice on cutting. The status of geography in the world of learning and affairs, on the whole a rising status, testifies that we are doing it.

Ackerman and "Fundamental Research"

As a starting point to our discussion of geographical reassessments, we may take the brief but solid contributions of E. A. Ackerman (*Geography as a Fundamental Research Discipline*) and Richard Hartshorne (*Perspective on the Nature of Geography.*)[2] Both of these, I think, are "musts" for serious geographers. In the new and important sense of "regional" as concerned with a distinct spatial theory, there is also a lively, though as yet perhaps somewhat inchoate, activity in numerous papers by quantifiers and regional scientists. Their approach is more abstracted than that to which geographers have been accustomed, and revives in a more refined form the idea of "regions" as concrete realities. This idea has been generally abandoned by geographers, who see in regions either convenient isolates for study (at times little more than boxes for data), rather dubious metaphysical concepts, or at best—and I

[1] I have elaborated this point in "'Region' as a Term of Art," *Orbis* (Philadelphia), Vol. I No. 3 (1957), pp. 343–51.

[2] Ackerman: University of Chicago, Department of Geography Research Paper No. 53 (1958); Hartshorne: Rand McNally, for Association of American Geographers (Chicago, 1959).

think it is often a very good best—subjective images, mental constructs which can be very illuminating and which have indeed some correspondence with real referends, provided we realize that these referends are not fixed things-in-themselves but incompletely precise apprehensions of reality, shifting though not evanescent. There is much valuable insight to be gained from this last idea of the region, but the irritant counter-stimulus of a more abstract model is perhaps essential as a stiffening: a warning against falling completely for either side of a dichotomy ("real" versus "construct") which may turn out to be largely notional after all.

At all events, whether we like it or not, regionalism of a new sort has broken loose from strictly geographical parental control, though in my opinion this breaking away need not spell catastrophe for the family welfare. As things have turned out, it is perhaps the chief defect of the contributions from Hartshorne and Ackerman that the former makes no reference and the latter little reference to Isard and this new school. The trend —if that is not too weak a word—has produced plenty of reforming zeal, but not as yet much in the way of programmatic synthesis, though hints towards a manifesto are not lacking. I will discuss the hopes and fears which it evokes in more detail later in this paper.

There is a great deal worthy of discussion in Ackerman's short but tight-packed pamphlet, though some comment may be subsumed in dealing with Hartshorne. Perhaps Ackerman's most important independent contribution is the stress on distributional *change* as a "near-universal" object of study. Allied to this stress is his recognition of erosional and depositional processes as the major non-constants of the physical milieu. These concepts, it seems to me, if fully refined and followed up, could provide an important integrative factor between the "human" and the "physical" sides[3]—more subtle than Jean Tricart's interesting Marxist manifesto,[4] but probably leading to conclusions more favorable to genetic geography than those in Hartshorne's *Perspective* (Ch. VIII), which I feel to be the weakest links in his argument. Very important also are Ackerman's remarks on "space-adjusting" and "resource-converting" techniques, remarks which link on to the new functional concepts of regionalism discussed below.

The need and the opportunities for fundamental geographical research increase with the intensification of human activity, itself a resultant, amongst other things, both of new technologies and of the mere multiplication of human beings. This Ackerman clearly shows. But Ackerman adds the salutary warning that such research can as yet hardlly lend itself to large-scale synthesis — the dream of all who think of themselves in some sense, however humbly, as scientists. In Ackerman's phrase, such research must be as yet disaggregative because at this stage there are simply too many things to learn about the new tools lying to our hands or indeed thrust upon us. This warning certainly has much point for old-style geographers like myself, who now and then are tempted to see ourselves as "near-universal" geniuses.

But the warning may also have some point for adepts in the newer methods, carried away as innovators always are, and on the whole properly, by the sheer thrill of their innovations — and so sometimes inclined to think that they have found the universal key. It is not only proper but necessary that from time to time ardent spirits should attempt the heroic task of *the* synthesis; without this temperament, we should never get anywhere. But many of us, whether we know it or not, stem from the great tradition of English empiricism — Bacon, Hobbes, Locke, Hume — and, while applauding the spirit of the Universalists, are very rightly suspicious of their findings. The systematizing urge does sometimes carry the risk of supersonic flight out of all rational orbits.

Hartshorne and "Relationships"

I think that undue importance may be attached by some to the revision, at an early stage of Hartshorne's *Perspective*, of the formula that "geography is the science of areal differentiation." It is not in any sense a recantation or a jettisoning of the old concept; simply a recasting, a spelling out of it into

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[3] I use " 'human' and 'physical' sides" without prejudice to the question of their really separate identities, but as "isolates for study"; in this sense we all know that they have an existence nonetheless important for being largely subjective; but see below.

[4] J. Tricart, "La Géomorphologie et la Pensée Marxiste," *La Pensée* (Paris), No. 69 (1956), pp. 3–24.

"geography is concerned to provide accurate, orderly, and rational description and interpretation of the variable character of the earth surface" (p. 21; italics in original). With this, who can reasonably quarrel? Yet there is room for diversity in unravelling the implications of even so cautiously qualified a formula as this. Hartshorne, for example, does me the honor (and these words are meant sincerely and not in the least ironically) of meeting an old point of my own by pointing out (p. 18) that on such a view relationships are indeed included; but on the further question of *what* relationships are significant, and *how*, we may still diverge. Ironically enough, indeed, it would apparently be the extremists of Determinism and Possibilism who would meet on the priority—not admitted by Hartshorne, if I read him aright—of Man:Nature relationships to our study.

I make no apology for introducing once more these time-hallowed terms. We do not need to consider "relationships" as *synonymous* with Man:Nature relationships (pp. 55–56) to recognize that these are very important ones; nor is it enough to declare that environmentalism arises as it were from environmentalism simply because if you think there are causalities you will find them. Certainly argument may be biased by an *a priori* determination, albeit subconscious, to find conditioning "laws" in the Semple manner, though even Semple deserves mitigating qualifications, as Hartshorne very fairly points out (p. 56). Yet pure induction — it is a truism — is just not possible, is not a feasible method of coping with the multiplicity of data; one cannot even start without some ideas of relevance and significance, as a rule if not indeed invariably inherited. (And who are we to repudiate the inheritance of three millenia of better brains?) As Preston James puts it, "in spite of the ever-present and essentially human temptation to find what one is looking for, one can not well go to the extreme of refusing to look for anything"[5]—which latter is pure induction. At the same time, we do well to remember Hartshorne's warning (p. 52) that an undue presumption that "human features" are effects and "natural features" causes may lead to an unwarranted discounting of the reciprocal causative effects of human activity—a belief in which, however, is quite consistent with a modest geographical neodeterminism. I feel no inconsistency at all in maintaining the direct conditioning action, in certain contexts, of "physical factors" together with an insistence on the importance of cultural factors to an extent not recognized by the purists of "this-is-not-geography."[6]

There are some Man:Nature relationships so simple and universal that they may be counted among the "naively given phenomena" recognized from the very beginning of coherent human thinking: the elemental relationships, one might say, of men with air, earth, and water. Not for nothing is Hippocrates' *On Airs Waters and Places* given a place of honor (temporally the premier place) in the history of our subject, however naive its method and detail.[7] With all the refinements of technologies and argument, these basic relations are not without power even today. And it is surely presumptuous simply to set aside the long tradition of common human experience, a tradition more inductive than deductive, empiric rather than *a priori*. (I speak not of the aberrations of, say, geomancy and astrology, but of the solid common-sense observation and reflection of mankind, which by and large goes wrong in the measure in which it is deductive.) That tradition is that man's fashioning of his home is far from a free choice; he may have revolutionized the aspect of large tracts of the earth's surface, but his revolutions are — or perhaps today I should say have been — rather law-abiding.[8] And, as we pitch more and more radiation into air, sea, and earth, we may find that we

[5] Preston James, "The Field of Geography," in *American Geography: Inventory and Prospect* (Syracuse University Press, for Association of American Geographers, 1954), p. 15.

[6] Cf. O. H. K. Spate, *India and Pakistan* (2nd ed.; London: Methuen; New York: Dutton, 1954), p. vii; J. E. Spencer, *Asia East by South* (New York: John Wiley; London: Chapman & Hall, 1954), p. vii; W. R. Thomas, Jr., *Land, Man and Culture in Mainland Southeast Asia* (the author, University of California, Riverside, 1957), *passim*.

[7] And hence, naturally, the Aunt Sally for Toynbee's discussion of environmentalism. See *A Study of History* (abridged ed. by D. C. Somervell; London: Oxford University Press, 1946), pp. 55–56. One does not demolish atomic physics by refuting Lucretius.

[8] Cf. Spate, *The Compass of Geography* (Canberra: Australian National University, 1953), pp. 13–14.

have revolutionized our environment to a degree all too determinative of our destiny.

Some of the confusion is semantic. "Influences," for example, have been banned, and yet *influence* — both etymology and normal usage show — denotes not a total and automatic control, but only one strand in a complex of conditioning, one element in a resultant of forces. I do not think that the question can be entirely begged by James's distinction between a changing and a relatively stable environment; in the former case, whether due to physical or biotic processes, "a positive determinism can exist." But allowing for the fact (an odd one to be overlooked by anti-environmentalists) that environment is inseparable from the environed, can the existence of any relatively stable environment be "demonstrated by acceptable method"? Those environments which seem least changeable—ice-caps, deserts, great ranges — seem also most conditioning. James is quite correct in saying that correspondence of patterns is far more common than coincidence; but this negates only the extremest and crudest environmentalism, that which expects a strict and rigorous application in detail. Application is limited by qualifications such as those suggested in discussion of the word *influence*, by considerations of probability rather than either strict necessity or mere possibility, and by concepts analogous to a margin of error.[9]

I do not think, then, that the problem is outmoded — else why must Hartshorne still discuss it after so many closures? Nor is it merely verbal; we need not be afraid of the semantic fireworks of logical positivism, themselves, if one may so put it, now under fire. In strict philosophical language, "determinism" is the wrong word to employ, unless, like Victor Cousin, we wish to assert a total, completely necessitarian control by physical geography;[10] but of course environmentalism can legitimately be recognized as one component of a general determinism. In not a few ways and places, and to a significant degree, human activity is affected by external environment—that is all that neo-environmentalism claims, and it does not rule out causative effects of human effort. But the attempt to rule out environmentalism leads to difficulties.

It is not really a demonstration of the invalidity of studies which "seek to determine the relation between human and natural factors" to say with Hartshorne (pp. 53–54) that "no sound conclusion can be drawn until the study is complete, which will generally be impossible," since further investigation may remove some errors but introduce others. Of how many complex bodies of knowledge or theoretical approaches could this not be said? How, if this dictum were acted upon, would there ever have been scientific thinking, except in mathematics? It seems to me that here Hartshorne does not quite measure up to his usually rigorous standards: environmentalist studies "*did not*" produce increasing certainty, though some "appeared more convincing"—"but *one knew* that later still more thorough research *might* appear to demonstrate entirely different conclusions." The italics are mine; they point up a shift of emphasis which seems revealing rather than convincing.

"Physical" and "Human"

At other points also Hartshorne's discussion (pp. 65–66) of the important question of physical:human dualism seems to me not quite successful. For the dualism to be valid, there are two criteria: "within each division the categories of facts studied would be more nearly similar," and the line between the divisions "would rest on readily observable distinctions in the naively given facts." The lack of homogeneity on each side must be readily admitted, and while I do not feel that it carries quite the weight which Hartshorne places on it, it is very true that the dualism is often overdone, and that this leads to the fallacy of failing to ask, "Environment for what?" Nevertheless the problem is far from simple, and it seems to me that when Hartshorne claims that "even after laborious research by many able scholars it may not be possible to separate features of the earth resulting from nature exclusive of man from those that result primarily from man," he may be liable to misinterpretation.

At first sight, one is tempted to retort in terms of naively stated facts. We might sug-

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[9] Preston James, *op. cit.*, p. 13 (note also the convenient relativity of "relative"); Spate, "How Determined Is Possibilism?" *Geographical Studies*, Vol. IV No. 1 (1957), pp. 1–10.

[10] For the point beyond which environmentalism cannot go, see Cousin's famous passage cited in L. Febvre, *A Geographical Introduction to History* (London: Kegan Paul, 1932), p. 10.

gest, without laborious research, that there are such features on the natural side at least: the oceans, the icecaps, the Himalayas. The rejoinder would have to be, one would think, "Ah, but *in their totality* some aspects of these features — shipping routes, weather stations, mountain villages — do result from man." However, with characteristic subtlety and caution Hartshorne has parried the surrejoinder that if one uses the qualifier *primarily* one is not entitled to use *in their totality*— and yet, contemplating the scale of man's works with Antarctica or the Himalayas, this might seem an inescapable phrase. But then there is the significant difference: *exclusively* from nature, *primarily* from man. Unless indeed the variation is merely stylistic, our naively given response is estopped—but then there is a looseness of expression unlike Hartshorne's norm.

Yet—assuming that it is semantically deliberate—why the distinction, unless to reflect a definite difference between two sets of phenomena, of which one could conceivably be exclusive of the other while the other could not? In simpler words, the earth could and did exist with no men on it, but living men so far can exist only on the earth. Of course in the former case there would be geography only in the sense that Martian astronomers could produce a geographical handbook to earth; but there could still be at least that sort of geography, and it would be a geography of features "resulting from nature exclusive of man."

All this may seem over-subtle, but it is not merely trivial verbalistic debate. For it seems to me that the sentence we have been discussing leads back to the old question that Hartshorne sets aside, that geography is primarily a science of man:earth relationships. Totally speaking, of course, the reaction of man to the Himalayas does not result exclusively from nature but is a function of both parties, and a total geography of the Himalayas must count man in. But differences of degree may be virtually equivalent to differences of kind, and we must look to the scale of the contributions of each factor. From this angle, the Himalayas were there first, existed in their own right, and Himalayan man exists not so much in his own right as by his acceptance of and adjustment to a complex of pre-existing features originally "resulting from nature exclusive of man" and still very dominantly "natural."

Whether or not this discussion is laboring the obvious, there is here a dilemma of much significance to the scope and unity of geography. From a "common-sense" point of view, most people would say that Antarctica and the Himalayas are "naively given" feature-complexes which "result from nature exclusive of man," except that he has named them; although of course there may be, as time goes on, more and more interpenetration with features of human origin. The attempt to unravel this argument, however, seems to me to involve study specifically, perhaps even primarily, of man:earth relationships. But such study, we are told (p. 64), is an error introduced by environmentalism—in spite of the fact that it perhaps reaches its fullest expression in such anti-environmentalist utterances as Kimble's definition of modern geography as "the study of the localization of ways of living . . . [primarily] viewing the earth as the home of human communities and cultures."[11] There would always be geological study of the Himalayas, but only geological study, unless on this "relationships" line. In an effort to avoid this dilemma, are we not likely to fall into the error likewise repudiated by Hartshorne (p. 18) that "geography is *limited* 'to the distinguishing of areas' "? Perhaps a lurking consciousness of such implications is in part responsible for his distinctly cautious and qualified acceptance of genetic geomorphology later on (pp. 86–96); although there is such acceptance (e.g., on pp. 89–90, it is in my opinion unduly hesitant, so much so that a virtual dismissal might easily be read into these pages by a careless student. Kimble's is of course an unintended *reductio ad absurdum*: we have come a full circle, and one cannot see how one can have a geography of Antarctica, except very deviously through its effects on New Zealand weather and hence on dairying — which of course would be acceptable enough to most New Zealanders!

Hartshorne's formulation here seems to me to carry at least some risk of leading into this circle. His objective, to maintain and emphasize the unity of the subject, is very proper; but his argument, at any rate when filtered

[11] G. H. T. Kimble, "The Craft of the Geographer," *Canadian Geographical Journal*, Vol. 31 (1960), p. 257.

through minds less dialectically skilled, might tend to exclude very important factors of areal differentiation, and to darken counsel by confounding groups of phenomena which, as isolates for study, are properly distinguishable.

The Dodo That Won't Die: Determinism

In all this, I do not wish to suggest that necessarily and indubitably I am right and Hartshorne is wrong. I have far too much respect for his general thesis and powers of argument, and even were my respect much less than it is, the question is not a simple one. I do suggest that there is still much hard thinking to be done on this knotty and intractable and very central problem. Meanwhile, we have been assured that determinism is as dead as the dodo. But it seems singularly tough for an extinct animal: an Immortal Bird, not born for death. How often has its Positively Final Appearance on Any Stage been billed, how many self-appointed exorcists have laid the ghost to their own satisfaction! And yet it still walks abroad, a lively spirit — because it images a real and ever-recurrent problem of our life on this planet on which we live and move and have our being. And if we do move on, shall we escape the Influences of Selenography, or the Martian environment?

Doubtless there is inconsistency in the polemical passion with which some determinists defend determinism. If it is true, in a way it need not and cannot be defended. But this is a psychological rather than a methodological problem, and far from unprecedented: witness the ethos of Muslims, Calvinists, Communists, all in their theory fatalists, all in their practice so often ardent exponents of the Will. As Hartshorne points out, subatomic indeterminancy has little relevance to the problems with which social scientists have to deal. Whether or not a "question of philosophic faith" has relevance for geography, for anyone but a logical positivist it has much relevance for the attitude of individual geographers to their work. In this sense, if not in Hartshorne's, it does have its place in scientific discussion.[12]

[12] But cf. A. C. Montefiore and W. M. Williams, "Determinism and Possibilism," *Geographical Studies*, Vol. II, No. 1 (1955), pp. 1–11, and my comment in *Geographical Review*, Vol. 48, No. 2 (1958), pp. 280–83.

But I am probably delaying too long on these epistemological disputes, and probably also giving an exaggerated impression of differences of opinion. Even when one disagrees with a formulation or the emphasis placed upon it, these pages of Hartshorne's are in many ways invaluable. For example, I feel that it is only on a very narrow view of our world that Hettner's generalization "time steps into the background" is true and useful, and that there are inconsistencies in Hartshorne's discussion of it (Ch. VIII); yet it leads to a warning, much needed by young historical geographers (and *mutatis mutandis* applicable in other contexts), which might be summed up by saying that one rarely has to begin in the Pre-Cambrian. And for the later chapters of *Perspective* there can be little but high praise; those philosophic doubts which so often and so needlessly disturb geographers intimidated by the claims of scientism here meet a quiet, a modest, but in my opinion a triumphant solution. The discussion of the place of prediction in science and the role of "scientific laws" (pp. 166–69), leading to the conclusion that the right question is not, "Is geography a science?" but, "What kind of science is geography?"; the demonstration, based on Hettner (pp. 173–78), that each of the systematic, chronological, and chorological approaches "extends theoretically over the whole of empirical knowledge," and that each includes some elements of the others—these concepts are especially elegant and valuable.

Down With Dichotomies!

Here Hartshorne is reducing to their proper proportions those seductive dichotomies which bedevil so much methodological discussion: physical versus human (my particular reservations above do not preclude general agreement), arts versus sciences, nomothetic versus idiographic, intuition versus ratiocination, in our own jargon regional versus systematic, and so on. All of these do in a way correspond to something, but not to absolutes. They are real enough if regarded as approaches, conveniences for the handling of data, functional emphases, mental constructs. It is essential to make use of them. But if they are regarded as things in themselves they lead only to a blinkered view of the Cosmos. As Hartshorne puts it in a rather more general context (p. 179, my italics):

> The organization of knowledge does not require a neat division into compartments, which would in fact be in violation of the essential unity of reality, but rather the recognition of coherent and manageable but *preferably* overlapping divisions.

The Altogetherness of Things — we will never really comprehend it, but if we fail to see that all these dualisms have a dialectic interplay, we shall never even apprehend that there *is* a cosmic unity. It is true that the magnificent archetype so deeply rooted in the thought and feeling of all peoples—*yin* and *yang*, male and female, light and dark, inner and outer (the list of couplings is endless)—is perhaps the most universal way by which we do apprehend Cosmos. Even if we think of Cosmos as a whole, as an emanation of some unitary Absolute or Godhead, we apprehend its manifestation in such dualities. But always it is neither the one nor the other alone which gives coherence to our vision, but the two together, without which there is no consummation — and this word is used in no restricted sense but in its full etymological connotation. Or even, perhaps, it is not merely fanciful playing with numbers in the Pythagorean manner if we now and then think, like Hegel and some Hindus, in Triadic terms: thesis, antithesis, synthesis. But never in terms of a single approach, a single factor, a single key: that way (sometimes literally) madness lies.

The foregoing may appear to be a romantic digression: that it has some relevance may, I hope, appear in my concluding paragraphs. Meanwhile, to come down to earth—a most proper thing for a geographer to do—I would repeat that Hartshorne's concluding chapters, and especially Ch. X ("Scientific Laws or Individual Cases?"), seem to me required reading. One need not agree but one must compare; one must weigh one's own evaluations on the precise scales provided by Hartshorne's meticulous argumentation. Here is the acid test by which one may assay one's own formulations and decide whether they express what one really thinks, or only what one thinks one thinks, a salutary exercise! The danger, of course, is that while Hartshorne is an invaluable irritant for those who are willing to endure the pain of thinking, he is too easily taken as gospel by those who are not so willing. One cannot justly blame a man for doing his work too well; but his assurance, his erudition, his anticipation of objections, his thoroughness — these provide very comfortable shelters for the timid and the lazy.

New Concepts of Regionalism

This thoroughness of Hartshorne's shows to advantage in his discussion of the newer concept of the region, dependent not so much on the integration of various elements in "areas of a certain type" as on "interconnections of places." Not all his points on the older concept seem to me well taken, but on the whole the argument pays off, while his discussion of the newer type appears a considerable improvement on Whittlesey's.[13] Here too we have a realistic and effective use of dichotomy: both concepts can be effective tools of research, but they should be clearly distinguished. Of course, as Hartshorne duly points out, the integration-type region may be marked by functional interconnection within itself; and, one might add, in some cases this may be among the more significant criteria in establishing it.

For the two types Hartshorne, following Carol, proposes the terms "formal" and "functional," and these seem to me entirely acceptable, as Whittlesey's "nodal" for the latter does not. In the case of functional regions "the unity of area involved is a reality based upon dynamic connections among phenomena at different places . . . therefore . . . the expression of a theory of process-relationships" (p. 136). Since such relationships are often readily susceptible to abstract statistical treatment—in which theoretical models may play a valuable part, as they rarely (not quite never) could in "formal" regions—this leads me to the ostensible subject suggested by the original title of this paper: Geography and quantification. It may be reasonably suggested that I have been a long time getting there; but I think we must blame Hartshorne for that. . . .

[13] Derwent Whittlesey, "The Regional Concept and the Regional Method," in *American Geography: Inventory and Prospect* (1954), pp. 37–40; cf. Hartshorne, *op. cit.*, pp. 129–42, and Ackerman, *op. cit.*, pp. 15–16, 28–30. It seems odd, incidentally (even allowing for the American context) that in a discussion of several pages (pp. 47–51) on the need for hierarchy, Whittlesey should not mention J. F. Unstead's careful and potentially fruitful proposals in "A System of Regional Geography," *Geography*, Vol. XVIII (1933), pp. 175–87.

II. REGIONAL SCIENCE AND QUANTIFICATION

The Rise of "Regional Science"

Perhaps any discussion of these problems of abstraction and quantification, which, though related, are not quite the same thing, should range around the work of the "regional scientists." Whether we like it or not, regional science is set for an independent existence. If, as Preston James says, geography has mothered it without much joy in the conception, perhaps that is because there seem quite a few claimants to paternity: economics, statistics, sociology. To me, regional science already meets at least one of James's two criteria for existence as a discipline. Admitting that I have no statistical competence whatever, I do not think that this is a case of *omne ignotum pro magnifico*; perhaps for most of us, *pro ridiculo* is a more natural reaction, and we greet the Unknown with a sneer. I am sure that such a reaction would be disastrous for geography. (As George Stevenson remarked when asked whether a collision between his new-fangled locomotive and a cow would not be awkward, "Very awkward—for the coo.") Quite as disastrous would be simple capitulation to the claims of some more extreme missionaries of quantification.

The first of James's criteria is that a discipline must be "in its own right, a contemporary reflection of a process of growth." Whatever else it may be, regional science is also just that. And I think that it is at least in process of meeting the other criterion of possessing "a body of tested and accepted procedures and a set of concepts"[14] — even if both procedures and concepts must in varying measure be shared with other disciplines. Geographers, of all people, are hardly entitled to object to this sharing!

If anyone doubts the lustiness of this infant, let him go through the five annual volumes so far available of *Papers and Proceedings of the Regional Science Association*.[15] It is not indeed necessary to plow through the lot—I have certainly not done so. But I would draw particular attention to Walter Isard's "Regional Science, the Concept of Region, and Regional Structure" and Morris Garnsey's "The Dimensions of Regional Science."[16] Both of these are extremely important, and it is important also not to be put off by the provocative air of some of Isard's sentences; allowance must be made for the fact that his paper is in some sort a manifesto, and of their nature manifestoes must be forcibly expressed.

Isard, for example, remarks (p. 13) that if we do not vigorously experiment with the new methods,

> . . . we shall thereby be forced to rely on inferior additive processes . . . e.g. the addition of elements of regional economics, regional sociology, and regional geography. As a consequence, we shall fail to capture the essence of the region. . . .

This does not, as a hasty reading might suggest, *in itself* mean that regional geography is something *per se* inferior: only that the borrowing would alloy the purity of the type of abstract regional constructs which Isard sees, perhaps rightly, as the most promising line of advance. One may of course disagree, and it is essential here to hold firmly to Hartshorne's distinction of formal and functional regions. For the first, I think that (as of today at any rate) in the last resort we can only grasp the essence of regions, or a region, by a geographical empathy akin to the historical empathy demanded in Croce's famous passage about the Ligurian peasant,[17] and indeed some element of "identification" seems to me to mark the best regional writing. But for the pure Platonic Idea of the Functional Region, Isard may well be right, although it must be said that in places (e.g., p. 17) he does seem to extend this "essence" as if it were more than the Idea, and here at least he seems to adopt an over-zealous attitude, moderately expressed but capable of degenerating into exclusivism, if not arrogance.

More than one of Isard's ideas — perhaps designedly, to provoke discussion — seem to play a little incautiously with a grand general

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[14] Preston James, *Papers and Proceedings of the Regional Science Association*, Vol. 4 (1958), p. 26.

[15] These volumes, hereafter referred to as *Papers and Proceedings*, are published by the Regional Science Association, Wharton School, University of Pennsylvania, Philadelphia 4.

[16] *Papers and Proceedings*, Vol. 2 (1956), pp. 13–26 (Isard) and 27–39 (Garnsey). Text references to Isard are to this paper.

[17] Croce's *locus classicus* is probably most readily accessible in R. G. Collingwood, *The Idea of History* (Oxford: at the Clarendon Press, ed. 1946), p. 199. There are of course qualifications to be made, but the central idea has wide acceptance and seems to me profoundly stimulating.

schematism, that desire for an all-embracing system which has seduced so many fine minds. He appears to believe in the region as, in certain contexts, "a concrete reality" (which for *functional* regions might be corroborated by Hartshorne's "the unity of area involved is a reality . . . ," quoted above[18]), and envisages the logical possibility of a "true" set of the best regions — and this definition few geographers would now be bold enough to accept. It has been effectively criticized by Arthur Maass[19] and by Preston James; the latter, beginning with the point that geographers must deal with concrete field phenomena ("concrete" of course does not mean only material objects) and regional scientists with "symbols for things they have never seen," goes on:

> . . . we must reject the idea that the description of any kind of process can be made so complete and all-embracing that "the last *ceteris paribus* will have been removed." "Other things being equal" is an essential symbol for all those sciences which aim at isolating specific phenomena, and which define their fields in terms of the subject-processes investigated. When processes are examined in particular places, other things can never be equal. This is a field which has long been defined as geography.[20]

To the point of this passage, and of a similar protest of Collingwood's, I shall return. The excessive discounting or dismissal of variables has also been criticized—in my opinion, most effectively—by Lukermann, who points out the numerous difficulties, both theoretical and empirical, besetting those who, in a mechanistic manner, simply equate space with metrical distance.[21]

But in any case, Isard himself, when one reads him closely, makes *some* of the appropriate qualifications. Perhaps his point of view is best summed up in the following passage:

> Generally speaking, the region may be both a concept and a concrete reality. Yet in certain contexts the region, either as a concept or concrete reality, disappears into thin air and leaves as a residue a continuous set of points in space. Identified with this context is an extreme degree of abstraction, which, nonetheless, furnishes one fruitful approach to the development of the concept of region. (P. 18.)

This last sentence appears an unexceptionable claim, though it must be balanced against what seems to me an unwarranted territorial expansionism on the preceding page — the procedures of regional science "should involve the reformulation and synthesis of existing concepts [in other social sciences] though to a decreasing extent as progress is achieved." Does this mean anything except that other fields will become superfluous? Again, one must protest vigorously against the very odd and indeed completely unfounded notion (p. 19) that the "earth-bound analysts" in these other sciences, for whom there is no " 'true' or 'fixed' set of regions relevant for all problems [but] simply generalizations of the human mind," are *not* "deeply concerned with the broad welfare objectives of society." This assertion is nothing but a dogmatic value-judgment, and one may meet it with another, less dogmatic — that breadth of this kind, which apparently needs "the ultimate in general theory" for its satisfaction, may very likely not be compatible with depth of understanding.

This statement of Isard's does not stand alone, and one may perhaps digress for a moment to consider the social implications of this approach. This true or fixed set of regions relevant for all problems—a very determinist, if not mechanist, concept—what is the point of it, if it is *not* simply a generalization of the human mind? As that, simply as an abstract model, it may well be valuable, despite all its omissions; but surely such statements as that just quoted imply more — that these models are blueprints for social planning. And here there is a revealing footnote in one of Isard's most substantive works: ". . . a 'pure' theory *such as is relevant to social planning* [my italics] rather than a 'realistic' theory wherein institutional forces are duly considered."[22] (It is not meant to imply, one assumes, that pure theory considers such forces unduly.) But on what definition of "social" can one legitimately leave out institutional forces, since society is just that—institutional forces? Presumably the pure theory, unlike earthbound analysis, will somehow help to maximize so-

[18] I understand from a personal communication that Hartshorne is now not entirely satisfied with this position.

[19] *Papers and Proceedings*, Vol. 2 (1956), pp. 40–43; cf. R. A. Platt, *ibid.*, pp. 46–47.

[20] *Papers and Proceedings*, Vol. 4 (1958), p. 24.

[21] F. Lukermann, "Geography: *de facto* or *de jure*," unfortunately an unpublished paper.

[22] *Location and Space-Economy* (John Wiley, and Technology Press, M.I.T., 1956), p. 182, fn. 13.

cial welfare. Why and how? Only, so far as I can see, if the true and fixed set of regions is regarded not just as an abstraction to aid in understanding a general dynamic, but as a pure master plan for the region/country/world, to which everything else must be subordinated. Except in the sophistication of technique, this reminds one, irresistibly, of the doctrinaire constructs of the early Utopian socialists such as Fourier and Cabet: evenly spaced communities at such-and-such distances with so-and-so many citizens for each type, *X* acres per man and trust in Providence that each man has *Y* children (or, of course—we've improved—birth control and artificial insemination). Such are the pleasures of abstraction. Not that the intent of the regional scientist is in the least totalitarian, but to this earthbound analyst that seems the logical meaning of what is said.

Nevertheless, there are other things in Isard's regional views which very usefully supplement Hartshorne's discussion and are well worth study: for example, the relativistic nature of the concept of regional structure, the "slicing" of the total field for the analysis of particular types of problems.

Despite what seems to me exaggerated hope for the eventual omni-competence of regional science, the continued relevance of geography is implicit in Isard's own words (p. 26): regional science must include, as well as abstraction, empiric field enquiry "directly relate[d] to the unique characteristics of each place"; as James points out, this is geography. Neither the extreme view that regional science is "an unwarranted invasion," nor its converse that regional geography in the older sense can be written off, is necessary or helpful. Though I think that regional science is at least approaching the status of a separate discipline, like ourselves it is interdisciplinary, with a narrower range, on the whole, but perhaps a more technical approach.[23] I do not think that geographers have anything to fear from this rise of a new discipline, at any rate after the first fine careless rapture is over. Regional science may well act as a pacemaker for geographers—even if the pace is initially hot! All the same, in the last resort probably most geographers will be content to be, as they must be, "earthbound analysts" if the alternative is to be quite so space-happy as Isard is in extremer moments.

[23] For a balanced view, see T. R. Smith in *Papers and Proceedings*, Vol. 3 (1957), pp. 13–15, and the conclusion of Garnsey's paper cited above (Vol. 3 [1956]), at p. 39. Significantly, Smith speaks of Garnsey's as the "relaxed" conception of regional science, with presumably an implied contrast to Isard's.

The Rise of Quantification

Regional science is perhaps only the most spectacular expression of a trend which must be reckoned with. It is clear that in many, quite likely in most, branches of our subject there must be added to the core of basic skills some statistical *expertise* beyond medians and averages. Not necessarily every geographer will need these skills, just as not every geographer need know how to construct complicated projections. But he must know the properties of projections; even if he can normally get a specialist to construct the sort of projection he needs for a special purpose, he must know enough to be aware of why he needs it. Much the same applies to statistics; and increasingly young geographers will feel that they are not properly equipped without some statistical *nous*. (I am very relieved that I am not a young geographer.)

The rise of quantification has been startling in its suddenness. Of the papers abstracted in the *Annals of the Association of American Geographers*, those which employed statistical techniques of any sophistication in 1938 were at most 7 percent—more probably, *nil*. By 1958, the minimum which could be so regarded was about 15 percent, the maximum 25 to 30 percent. The Association now has special sessions devoted to measurement and statistical geography. This development is obviously here to stay. In 1954 *American Geography: Inventory and Prospect* included no chapter dealing specifically with geographical applications of statistical techniques. Such an omission would be very unlikely in 1960, and would probably occasion a legitimate outcry. Incidentally, I think that there is great need for one or more reasonably comprehensive texts on this topic to synthesize the more viable of the plethora of papers.

Humanist as I claim to be, I do not deplore this trend so far as it has gone. Quantification has increased, is increasing, and in my opinion ought not to be diminished but to stay—quantitatively—just about where it is

now. It is an essential element with a valuable role to play; but it is not without its dangers. These are mainly: (1) a tendency to confuse ends and means; (2) a correlative naivety which sometimes fails to distinguish between the trivial and the significant; and (3) a natural youthful ambition which to a point is innocent, or even laudable, but which beyond that point—hardly to be determined quantitatively—may be excessive and lead to the Original Sin of academic life—exclusivism or obscurantism. Be it noted that obscurantism cuts both ways: usually, and usually rightly, associated with a conservative view, it can yet be just as much a trait of the radical and the progressive.

Ends and Means

Confusion of ends and means is perhaps best seen in the rather naive resurrection of Lord Kelvin's famous or infamous dictum that "when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind . . . *whatever the matter may be* [my italics]."[24] The statement has validity in a limited context, though even there it is little more than a circular truism: "It is important to count what can be counted." That it is more than this I absolutely deny; yet because of its splendid Victorian self-confidence, it is seductive, and hence can be seriously misleading.

Kelvin notwithstanding, there *are* matters on which precise quantified statements may be far more meager and unsatisfactory, and far less meaningful, than statements which do not rest on statistical enquiry but of which the accuracy cannot be impeached. I have illustrated this elsewhere[25] from Madrid and Barcelona. Analyses, useful so far as they go, can be made from the occupational structure of these two cities, analyses which are statistically precise and valuable for a quantitative *description*. They are less meaningful—that is, they stand in more need of explanation and interpretation, of outside support—than conclusions drawn from the historical development of these two cities: Madrid the creation of a consciously centralizing state power, Barcelona the focus of an intense regional separatism consciously opposed to the centralizing symbol and reality of Madrid. Regional science here would certainly help to point up the contrast, but it would completely miss the point or essence, since this depends very largely on the intangibles of history and politics. From the point of view of understanding regional realities in Spain, if we had to choose there is little doubt—none in my mind—that we should choose the non-quantitative approach in this case. Fortunately we do not have to choose: each approach can illumine and support the other, and this should surely be our ideal.

Worse, perhaps, than this Kelvinian flourish are such statements as that quantified descriptions are the *goal* of scientific investigation. The goal of scientific investigation—of *all* scientific investigation, in which our individual investigations are as rills to the Amazon—is understanding of the Cosmos. To this end, quantified descriptions may be and often are very important means — sometimes essential, sometimes the *only*, means; *and yet, but means*. This is at least one dichotomy we must stick to. And one is tempted to add another: the difference between classifying and understanding, counting and judging! If we had full understanding, we should not need to classify, unless perhaps as a delegation or devolution to assist in presentation; as it is, we may well need to classify as an aid to understanding. But we should never mistake classification for comprehension.

Very naturally, those who have turned their attention to quantifying techniques and concepts — especially such things as "nearest neighbor theory" — have been much influenced by developments in the study of biological populations, especially in plant ecology;[26] indeed, in some cases such studies

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[24] Cited, e.g., in Ackerman, *op. cit.*, p. 12 (fn. 22), and in the introduction to Leslie Curry's Auckland Ph.D. thesis, "Climate and Livestock in New Zealand —A Functional Geography" (1958). I have seen, but cannot now place, a third very recent resurrection.

[25] "Lord Kelvin Rides Again," *Economic Geography*, Vol. 36 (1960), guest editorial.

[26] Cf.: B. J. L. Berry, "Statistical Tests of Value in Grouping Geographical Phenomena," paper read at 1959 meeting of the Association of American Geographers, p. 1; P. R. Gould, "The Geographical Application of Nearest Neighbor Theory" (unpublished MS, 1957), p. 1; M. F. Dacey, "Analysis of Map Distribution by Nearest Neighbor Methods," University of Washington (Seattle), Department of Geography Paper No. 1 (1958), pp. 3–5; P. J. Clark and F. C. Evans, "Distance to Nearest Neighbor as a Measure of Spatial Relationships in Populations," *Ecology*, Vol.

seem to have given the initial impulse. One of the most brilliant pacemakers in this field is indubitably D. W. Goodall. It would be well if one of his most pregnant conclusions were better remembered:

> In any case, quantitative methods can never be more than an adjunct to *description* — they can never provide *interpretations*. Interpretation is a process in the ecologist's mind when he has fully surveyed the descriptive data, whether qualitative or quantitative; and, while quantitative descriptions may greatly facilitate or even guide these mental processes, they cannot replace them.[27]

"*They cannot replace them*"—worthy of letters of gold! Another point of Goodall's well worth weighing is that "ordination"—precise designation by co-ordinates, as opposed to "the bare statement of class-membership" in some "stated region of the continuum"—can never be *wrong*, but it may be unnecessarily cumbersome.[28] This leads me to the second danger: the dogged analysis of trivia, the elaborate discovery of the well-known.

A la Récherche de la Platitude Absolue

The meticulous exploration of the realms of platitude—painstaking, but a standard refutation of the dictum that "genius is an infinite capacity for taking pains"—is no monopoly of quantifiers. We all know those careful qualitative descriptions of market-towns which take care to point out that the towns have markets. I recall a paper 'way back in the 30's which announced that the distant view of a prairie town of 150,000 people showed more tall buildings in the middle than one of 15,000. It seems to me that there is a distinct risk of *expertise* in a fashionable technique disguising an essential poverty of thought; and this is less easy to get away with in qualitative writing where there is no smoke screen of formulae. The *cognoscenti* have their own radar to see through it; the uninitiate may be completely bluffed.

In this field the most magnificent, the most sublime, examples come from sociology: such epoch-making generalizations (and this is not parody!) as that "perhaps" people have more frequent cordial and intimate contacts with their personal friends than with those who are not their personal friends; or that while one usually marries someone of one's own creed and class, quite often he or she is of somewhat opposing temperament.[29] There are, I am glad to say, signs that this compulsion to *look* scientific ("scientific" being equated with formulae) in sociology is working itself out. Common sense and decent American English seem to be coming in again. But it is because I do not wish such gross idiocies to disfigure geography that I would sound a note of warning. Already there are premonitions of this Hudibrastic diseconomy:

> For he, by geometric scale,
> Could find the size of pots of ale;
> Resolve, by sines and tangents straight,
> If bread or butter wanted weight;
> And wisely tell what hour o' th' day
> The clock doth strike, by Algebra.[30]

One cannot, for example, be altogether happy about some of the recent work on business location; it is parody, doubtless, but equally doubtless not always extravagant parody, to say that some of it seems not much more than a mathematical demonstration that there are a lot of motels on the more touristy stretches of U. S. 66. One must discriminate and make due allowances: not all that looks naive at first sight is quite so naive when looked at more closely—though in some cases

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35, No. 4 (1954), pp. 445–53. The last two cite directly Goodall's paper referred to in my next note. My attention was drawn to these papers, and indeed to the subject generally, by my student R. H. T. Smith.

[27] D. W. Goodall, "Quantitative Aspects of Plant Distribution," *Biological Reviews*, Vol. 27 (1952), pp. 194–245 (at p. 195).

[28] D. W. Goodall, "Vegetational Classification and Vegetational Continua," *Angewandte Pflanzensoziologie, Aichinger Festschrift*, No. 1 (1954), pp. 168–82.

[29] Although this last conclusion on mate-selection was arrived at by impeccably quantitative methods —"With 15 variables [variably dichotomized and double-dichotomized] into 44 sub-variables, the complete interspousal correlation consists of 15 times 15 (= 225) submatrices containing 44 times 44 (= 1936) elements . . ."—it is perhaps not fair to quote it against respectable quantifiers, since the generalization is based on 25 university couples, a restricted sample not likely to be of practical use to colleagues with adolescent daughters. There are odder things in a study of campus petting. For a general indictment—unfortunately spoiled by the all-too-obvious implication that the major offense is inadequate recognition of the author's primacy—see P. A. Sorokin, *Fads and Foibles in Modern Sociology and Related Sciences* (Chicago: Regnery, 1956); with due wariness of Sorokin's own Orientalizing foibles, it must be admitted that he makes many palpable hits.

[30] Samuel Butler I, *Hudibras. The First Part* (1663), canto I, lines 121–26.

repeated reading substitutes circularity for naivety as the offense. Some apparent triviality reflects a determination to take nothing for granted but to work everything out from first principles; but while this is an eminently proper way of thinking, it is rarely necessary in presentation, and it can lead to unhappy tautological expressions such as the "inference" that "highway-oriented functions are most successful when oriented along major highways." That is just what "highway-oriented" means, and one may question the argument or presentation that needs to spell it out; at the very least, it is open to misinterpretation. Nor, despite good will and some effort, do I find Berry's "four conformations of business" a very novel or a very striking discovery.[31]

At the same time, it is likely that from the work of Garrison, Berry, and their associates[32] there will emerge some useful basic generalizations which would not be reached through straightforward empirical observation alone. But it is interesting to note how much does seem to depend on verification from field observation.[33] This of course is as it should be; properly handled, the empirical and the theoretical approaches, the idiographic and the nomothetic, should support each other. The mistake lies in taking either for the one true and necessary way all the time; and, as we shall see, this mistake is being faithfully made. Nor should empirical checks of a theory be confused with substantive new knowledge, or its formulation equated necessarily with understanding, although it is in new and fruitful formulation that the real value of quantifying analysis chiefly lies.[34]

Considering the pressure for publication—almost any publication—which is a feature of the academic market-place, it is not surprising that some essentially trivial material will be printed, some of it little more than raw data, or merely interim descriptions of experimentation which should not really have a place in a considered presentation. Quantified or not, the trivial we will always have with us; it is just rather more maddening when presented with a patronizing display of new method. In time, these essentially empirical quantifying approaches will find their true level — not a low one — and be recognized for what they are: useful tools, not universal keys to knowledge.

The Sky's the Limit

Finally, there is the danger resulting from vaulting ambition. Some of this is innocent enough, in its spirit even laudable, as for example in the rather startling "Proposals to Develop Statistical Laws of Human Geography" by S. C. Dodds and F. R. Pitts.[35] At least the concept marks an advance on the crude law-making of the Semple phase, and has a certain curious charm. True, their Modest Proposal is not quite so breathtaking as Eugene Van Cleef's demand that "geographers must observe every square inch of the earth's landscapes,"[36] but it does suggest the assembly and maintenance, over the next fifty years or so, of up-to-date "geo-files" with cards for each and every "unit" of the earth's surface—say, each square mile (60,000,000 cards, plus or minus) or each "township" of 100 square miles (600,000 cards). All would be fed into computers, and out would roll those lovely correlations which would at last, at last, give us "laws of complete universality and high precision." It would of course be better to use person-cards (say — but for how long could we say it? — 2,500,000,000), each personal quantum of economic and social position correlating with the other data (altitude, soil, economy, climate . . . *ad infinitum*) on the respective unit card.

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[31] B. J. L. Berry, "Ribbon Developments in the Urban Business Pattern," *Annals*, Association of American Geographers, Vol. 49 (1959), pp. 145–55. I would like to emphasize that, while I find some aspects of Berry's presentation unsatisfactory, there can be no question of the scholarly and scientific spirit of his work.

[32] W. L. Garrison (ed.), *Studies of Highway Development and Geographic Change* (Seattle: University of Washington Press, 1959).

[33] See, e.g., the second half of Berry's paper cited in fn. 31, and of Gould's paper cited in fn. 26.

[34] This seems an appropriate place to call attention to an apparent tendency to use "empirical" as if it meant "deductive" or even "*a priori*," and "intuitive" to apply to *any* non-quantitative reasoning—even to "intuitive inference," a contradiction in terms.

[35] In *Proceedings of the International Geographical Union Regional Conference in Japan 1957* (Tokyo: Science Council of Japan, 1959), pp. 302–09. Several other papers in this valuable volume bear on topics discussed here.

[36] E. Van Cleef, "Must Geographers Apologize?" *Annals*, Association of American Geographers, Vol. 45 (1955), pp. 105–08. For succinct comment, see Hartshorne, *op. cit.*, p. 128.

Well, if geographers were kings . . . Yet it would be imperceptive merely to dismiss this proposal as a delicious dream. The argument — and the objections — are carefully worked out, and even if we think that the actual proposal must remain in the realm of fantasy, the paper contains a residuum of sensible and useful observations. And, paradoxically, once quantification were carried out on this scale, in a sense abstraction would be largely superseded: we would have an unsurpassable fund of empirical data, and the electronic tools for its analysis. And unless we could have a punched card for each and every human motivation—and changing motivations—there would still remain a vast field for interpretation. I confess that the prospect so dazzles me that I cannot but commend the spirit at least of these proposals.

It is otherwise when ambition co-exists with the pedantically elaborate discovery of the known by one single key, and the exclusivist assertion is made that this is the best, perhaps the only, way to discover it. I think that I am justified in taking as an exemplar a recent paper by J. Q. Stewart and W. Warntz: "Macrogeography and Social Science."[37] It begins by setting up an Aunt Sally called Microgeography:

> Complete spatial accounting is the goal of microgeography. [Yes, on the Van Cleef or Dodds-Pitts line: but that is not what is meant.] An accepted triumph is the production of a map showing the precise location of each discrete occurrence of the phenomena studied: the dot map is of course one of the most valuable examples. Such denotations have unfortunately become thought of as alone constituting the "geography" of the phenomena studied. . . .

Dear me! As if such a map were thought of as an end in itself and not as a tool; as if one of the most recurrent problems of geographers were not how to generalize on maps, rather than precisely spotting each discrete occurrence.[38] Of course some geographers — and others—do go in for mapping for mapping's sake and produce pointless triumphs in this line; but that any passably well-schooled geographer has ever thought that such things "alone" constituted his study I very much doubt.

The less critical and more substantive points in this macrogeographical approach, the concept of potential of population, may have serious value as analytical tools, though they have been criticized, in my opinion very cogently, in papers, unfortunately unpublished, by Lukermann and Porter of Minneapolis.[39] Both point out some very questionable logical assumptions involved in the concept of an abstract undifferentiated space —which seems the core concept of macrogeography and regional science—when applied to the actual world of phenomena distributed over the earth's surface. It is simply not true, for example—and we can all see this—that accessibility is simply a function of measured distance; yet this, or something very much like it, seems to be predicated in the general approach of macrogeography.

I have not Lukermann's philosophical equipment, and one cannot summarize his argument briefly. All I can do is to apply the excellent empiricist touchstone "By their fruits ye shall know them," to assess the results put forward as significant and the general temper displayed: neither is very impressive. In fact, one feels rather as the little boy in Andersen's story about the Emperor's wonderful new clothes: "But, Mummy, the Emperor hasn't got anything on!" When one reads that "a single, macroscopic, integrative index potential of population, as the leading concept in sociological intensity, introduces a powerful unifying concept," one begins to wonder: another *single* key to turn *all* locks? These demands for a mechanistic all-embracing "social physics" were heard long ago in sociology, where they now seem decidedly *vieux jeu*; are they now seeking refuge in geography?[40]

What novel insights are in fact given in this distinctly assertive paper by Stewart and

[37] In *Geographical Review*, Vol. 48 (1958), pp. 167–84.

[38] For a good example, see C. N. Forward and C. W. Raymond, "Small-scale Land Use Mapping from Statistical Data," *Economic Geography*, Vol. 35 (1959), pp. 315–21.

[39] F. Lukermann, *op. cit.*, in fn. 23; cf. also his "Toward a More Geographic Economic Geography," *Professional Geographer*, Vol. X, No. 4 (1958), pp. 2–10; P. W. Porter, "Does Geography Need a Social Physic?" unpublished.

[40] I cannot provide the clothes myself, though I suspect some decent garments might be cut from the concluding section of Lukermann's unpublished paper, on processes and levels of explanation. For "Social Physics," see Sorokin, *op. cit.*

Warntz? The results are summated in a series of maps, and seem to me distinctly jejune, in part, perhaps, because the contour interval is very broad (it has to be, to remain "macro"). They show, for example, the primacy of the metropolitan areas of New York, Chicago, and Los Angeles. Did these need showing?[41] (What would be valuable would be a much closer net to show the ranking of minor centers like St. Louis and Birmingham; this however might be "microgeography.") There are two maps of potentials in 1860, which have no point at all unless it is intended — and the captions make clear that it is so intended—to illustrate relative strengths in the American Civil War. It is carefully pointed out that Figure 6 "indicate[s] Southern vulnerability to Northern sea power." Winfield Scott grasped the point in 1861; even Jefferson Davis must have noticed it by 1865. That Stewart and Warntz in 1959 think it necessary to prove a historical commonplace argues a certain intellectual purblindness. It is true that, in conformity with the gradient of potential, "the stiffest and most prolonged fighting" did occur in Virginia; but this was the result of political stupidity (on both sides). One wonders how the gradient would have been interpreted had Sherman and the Western armies been given a free hand earlier. Of course the case is better if meant conversely, to show that the theory squares with an acknowledged fact. But not much better; the point is too much of a truism to help greatly in a general validation.

This point is not made merely for debate. This approach, useful as it may be in the gross as suggesting certain rough approximations (in much the same way as Marxist theory does), is determinist in an unsubtle and unrefined manner. It completely neglects Goodall's warning: it mistakes description for interpretation, correlation for causation. The result is a serious misconception: it gives a misleading appearance of absolute historical inevitability.

One does not dispose of a theory by analysis of some ineptitudes. But when, as in the curiously infelicitous jingle with which Stewart and Warntz adorn their conclusion, they simply write off other approaches as demanding "but little thought," we are entitled to look closely at their own style of reasoning. To me, it lacks logic and syntax.[42]

Credo

This is, like it or not, the Quantified Age. The stance of King Canute is not very helpful or realistic; better to ride the waves, if one has sufficient finesse, than to strike attitudes of humanistic defiance and end, in Trotsky's phrase, in the dustbin of history. And if the quantifying trend carries with it—as I think it does—the danger of a devaluation of human idiosyncrasy, of local color, yet it has also its hopes and opportunities: for a more verified and rationalistic perspective on the problems which confront us, as individuals and as a society, in this agitated age. It would be unfair and imperceptive not to respect the feeling that one is on an exciting new frontier of knowledge, that one may at last recognize and perhaps in the literal sense realize the whole rationale of human society. The Benthamites had this feeling, and before them the Encyclopaedists and the Hobbists, and after them the Marxists. It is almost certainly delusion, but a necessary sort of delusion: without this spirit we should still be cracking marrow-bones in caves.

Quantification presents an exciting new frontier, then, with rewards for the adventurous; but, conversely, has a frontier any meaning, can it even exist, without its core region? Here one comes back to "earth-bound analysis." As Lukermann puts it,

> We turn, and not reluctantly, to the explanatory narrative which alone integrates our categorized subject matter into the scope of human experience. It is in this use of the circumstances of the particu-

[41] It is apparent from a comparison of Figure 3 in the *Geographical Review* article under discussion with the map on p. 22 of Stewart's chapter "Potential of Population and Its Relationship to Marketing" (in R. W. Cox and W. Alderson [eds.], *Theory in Marketing* [Chicago: Irwin, 1950]), that the cartographical representation of results is affected, to an unacceptable degree, by the care and degree of generalization with which the isolines of potential are drawn. The relative values of Chicago and Pittsburgh are in fact reversed on the two maps.

[42] It is a relief to note the paper by C. T. Stewart, Jr., in the same number of the *Geographical Review* (Vol. 48, No. 2) on "The Size and Spacing of Cities," pp. 222–45. This paper does use quantitative theory and empirical data in mutual support, an excellent example of how rightly to use quantification. Incidentally, it casts some doubt on the general validity of G. K. Zipf's "Rank–Size Rule."

lar that we make use of the generic content of science and create a geography.[43]

Whether we turn this way or not is perhaps a matter of archetypal attitudes, the perennial antithesis like that between Platonist and Aristotelian, between the sons of Hermes and Apollo.[44] The problem concerns us, first and foremost, as human beings, and each of us, in the last resort, must make his own choice, take his own steps, if indeed he has any free choice in the matter. As a determinist, I doubt that he has. But if "freedom is the recognition of necessity," at least we may recognize it, and not beat ourselves to death on the enclosing walls. Within those walls there is as yet much scope for the play of individuality. I for one do not feel the death-wish so often ascribed to Western society at large by its open enemies or by faint-hearted over-intellectualized inmates.

This is a personal credo, for which I hope I may be pardoned, since it stems from the larger bearings of my theme — and we are shallow poor creatures indeed if we never stand back to look at them. More immediately, as geographers, as scholars devoted to a particular discipline, it may be helpful to reflect that we are not alone. In a kindred study the same problem arises—and the same vista. Professor La Nauze of Melbourne has evaluated the "Butlin revolution" in Australian historiography which (I take some vicarious pride in saying so) has been hatched in my own university:

> There are no people in it, but there is growth of population. . . . There is no elegant fun at the expense of the Italianate mansions of the 1880's; there is a statement which ten years ago might have been (but was not) guessed at, but which could not then have been based firmly on quantities: "The building of cities [in the period 1861–1900] absorbed the greater part of Australian resources devoted to developmental purposes."
>
> . . . Let there be no doubt that the economist–historian is saying things important for political, social, and even cultural history. . . . [But] history does not become statistics because the economist–historian insists that essentially quantitative questions must be answered quantitatively, nor would he claim that because all he has to say about religion is summed up in a table of figures headed "Gross capital formation: Churches" that there is nothing else to say about the subject. . . . If the economist–historians should claim that, because it is impossible to measure them, exaltations, agonies, freedom and love have no place in the writing of history, it would be a case not for alarm or for jesting, but for pity. But they have not made, and are not likely to make, any such claim.[45]

How very similar that is to the position of geographers! "People" — yes, we must keep them in; "elegant fun"—yes, there must be a place for that. I wish, considering some developments in sociology, and, for example, Isard's claim of how to grasp the essence of a region, that I could feel quite so sure of La Nauze's last sentence—but in the last resort, whether *they* like it or not, there will always be innumerable enclaves of individuality not accessible to punched cards; always boys and girls to whom "The Complementary Theory of Mate Selection" and its reference to "a formal definition of love" in two volumes won't matter a damn.

Finale

To sum up a long and involved paper, which yet has omitted much, it seems to me fair to say that *so far* the effect of the quantifying trend has been intellectually stimulating; yet, as Preston James reminds us, we must ever be wary of "the intellectually stifling effect of a clearly-stated but over-simple theory."[46] The crux, as it seems to me, is this: quantification is in the end essentially classificatory rather than truly interpretative, though it is often an essential tool towards interpretation. If we forget this, and let it become master rather than servant, we may lay ourselves open to Collingwood's criticism of Toynbee:

> He has not undertaken any philosophical analysis of the way in which his [geographical] knowledge has been attained. He possesses enormous quantities of it, but he treats it as if it were something he finds ready-made in books, and the problem which interests him is only the problem of arranging it when collected. His whole scheme is really a

[43] "Geography: *de facto* or *de jure*," *ad fin.*

[44] W. H. Auden, *Under Which Lyre?*—

> The sons of Hermes love to play
> And only do their best when they
> Are told they oughtn't;
> Apollo's children never shrink
> From boring jobs, but have to think
> Their work important . . .

This brilliant Phi Beta Kappa poem (1947) ought to be required reading for all aspirants or eminents in the academic world.

[45] J. A. La Nauze, "The Study of Australian History, 1929–1959," *Australian Journal of Science*, Vol. 32, No. 6 (1959), pp. 227–34; also in *Historical Studies* (Melbourne), Vol. 9, No. 33 (1959), pp. 1–11.

[46] *American Geography: Inventory and Prospect*, p. 15.

> scheme of pigeon-holes elaborately arranged and labelled, into which ready-made [geographical] facts can be put. Such schemes are not in themselves vicious; but they always entail certain dangers: notably the danger of forgetting that the facts thus pigeon-holed have to be separated from their context by an act of dissection. This act, become habitual, leads to an obsession. . . .[47]

Hartshorne also—with significant reference to sociology, a major victim — points to the tendency of enthusiasts in new and valuable techniques to lose their heads and maintain that

> . . . whatever is not amenable to analysis through such methods is not worth studying [there is usually a conventional disclaimer which deceives nobody]. . . . In a field in which the phenomena run the full range from cabbages to kings, from rainfall to religion, it would seem absurd to assert that all that is worth studying can be fully and correctly described in quantitative terms, or, conversely, that whatever phenomena can be described in quantitative terms are worthy of study in geography.[48]

Of course very few would be brash enough to *assert* these things; but not a few fail to notice that they *imply* them.

Hartshorne's words are unexceptionable as a general statement. But how shall we apply them in this special case? Here I will once more — it is my last extended extract — fall back on Preston James:

> What can professional geographers and regional scientists do for each other? Geographers can perform their usual function of bringing people down to earth, by insisting that regions are real places where real people live and work in a particular kind of land and where transportation runs along real roads, not straight lines on a diagram, or arrows in an algebraic formula. Do not misunderstand me. The application of the statistical method to this aspect of economic geography has tremendous possibilities and might well rescue economic geography itself from the frustration of empirical description [and, conversely, rescue theoretical economics from its tendency to airy-fairiness]. I hope that there will be enough geographers ready, willing, and able enough to join with the regional scientists in cultivating this border field. . . . But geographers have also been ploughing in this field for a long time, perhaps with inadequate implements. The concepts they have formulated regarding regions and the method of regional analysis must not be disregarded or overlooked by the regional scientist. The real strength of this mating may lie in the bringing together of cartographic and statistical methods of analysis.[49]

Amen, so be it!

It remains only to draw some threads together, in the spirit of Hartshorne's "reminder of the fact [so obvious; so often forgotten] that all sciences are but parts of a single body of knowledge"; all fields of study but parts of Cosmos. This paper is a plea for catholicity. So often we see dichotomies where there are really but groupings, perhaps not without overlap, along a continuum. And even where the dichotomies are real, they are so often—thinking of the earlier discussion of dualisms and triads, I would almost hazard "always"—*dialectically and not statically antithetic.*

Humanist, quantifier, what you will—it is never wrong to plug your own line; it is almost always wrong to write off others. That horrible little word "mere" and its analogues ("Oh, it's only on that level" and so on)—we should sit back and suspect ourselves whenever we use them. Whenever we are tempted to use them about an approach, a concept, a technique, which has behind it EITHER tradition and achievement OR the vitality of a new thing, we should stop and think and think again. *Mere* description, *mere* quantifying, *mere* abstraction—each of these in a certain context may be valid; but the habitual and indiscriminate use of them writes one off as a *mere* obscurantist.

Referring respectively to Toynbee and Huntington, I once spoke of Myth and Statistic as being "themselves but parts of Poetry and Science, which together make our vision of reality."[50] I am glad to find that, in much the same way of thinking, Julian Huxley, who ranks on the scientific rather than the humanistic side (if we must refer things to this dichotomy), has said:

> One of the great needs of our time is to discover means for coping with the problems of quantity and value: after all, our most important experiences are qualitative, and when everything has been reduced to mathematics, something essential has evaporated from reality.[51]

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[47] Collingwood, *op. cit.*, p. 163. "Geographical" has been substituted for "historical."

[48] Hartshorne, *op. cit.*, p. 162.

[49] *Papers and Proceedings*, Vol. 4 (1959), p. 26.

[50] "Toynbee and Huntington: A Study in Determinism," *Geographical Journal*, Vol. CXVIII, No. 4 (1952), pp. 406–28, at p. 424.

[51] In introduction to D. H. Rawcliffe, *Illusions and Delusions of the Supernatural and the Occult* (New York: Dover Publications, 1959), p. 6.

For this task of developing a balance, geography holds a position of the highest strategic value, linked as it is (and no other discipline has quite so wide a spectrum) with the arts, the humanities, and the sciences, whether physical, biological, social, or "in the field." We have still new worlds to conquer, new allies to enlist; or, to be more modest and more realist, new contributions to make to the Grand Alliance of learning.

THE GEOGRAPHIC RANGE OF THE HISTORIC BISON IN THE SOUTHEAST

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THE southeastern limit of the maximum range of the American buffalo (*Bison bison*) has been variously located during the last century, and is still in need of adjustment. A hundred years ago Spencer F. Baird said that the buffalo formerly ranged "throughout the eastern portion of the United States to the Atlantic Ocean, and as far south as Florida," a statement that expresses an opinion probably common among contemporary scholars, for many of them made similar remarks in their writings.[1] Not everyone agreed. Albert Gallatin did not believe that the bison in the East had ever been seen south of the Tennessee River valley, and in suggesting that river as a boundary he anticipated by forty years the opinion that became prevalent after the publication in 1876 of J. A. Allen's exhaustive monograph on the American bisons.[2] The map accompanying Allen's work, "designed to show the extreme limits of the known range," was somewhat modified by William Hornaday in 1887.[3] The Allen–Hornaday boundary, which excludes southern Louisiana, most of Alabama, half of Georgia, and all of Florida (Fig. 1), became generally accepted as definitive and has remained unquestioned for a long time; its influence can be seen in the numerous copies of it reproduced to this day in textbooks and other publications. However, Allen's southeastern limit was criticized as early as 1880, when J. F. H. Claiborne said that it fell far short of the actual range, and more recently other students have called attention to historical records of the buffalo that confirm the statement of Claiborne.[4] Consequently, much of the territory ruled out by Allen and Hornaday has been included on the most recent map of the bison range, that of Hall and Kelson.[5] But not even the line of Hall and Kelson represents the true limit of the maximum range, for there is evidence showing that it must be drawn farther east in Georgia, South Carolina, and North Carolina, and much farther south in the peninsula of Florida.

HISTORICAL RECORDS

Allen and Hornaday both thought that at some time in the past buffaloes may have wandered into central Alabama, Florida, and southern Georgia, but they denied the existence of any record of the animal in those

[1] Spencer F. Baird, *Mammals of North America* (Philadelphia, 1859), p. 684. For comments similar to that of Baird, see: J. E. Colhoun, in William H. Keating, *Narrative of An Expedition to the Source of St. Peter's River*, Vol. 2 (London, 1825), p. 21; John D. Godman, *American Natural History*, Vol. 3 (Philadelphia, 1828), p. 23; James E. DeKay, "Zoology of New York," Part I, in *Natural History of New York*, Vol. 1 (Albany, 1842), p. 110; John James Audubon and John Bachman, *The Quadrupeds of North America*, Vol. 2 (New York, 1851), pp. 54–55; R. B. Marcy, *Exploration of the Red River of Louisiana* (Washington, D.C., 1854), p. 112.

[2] Albert Gallatin, "A Synopsis of the Indian Tribes," *Transactions and Collections of the American Antiquarian Society*, Vol. 2 (1836), p. 139; also, *Transactions of the American Ethnological Society*, Vol. 2 (1848), Introduction, p. L; Joel A. Allen, "The American Bisons, Living and Extinct," *Memoirs of the Museum of Comparative Zoology*, IV, No. 10 (Cambridge, Massachusetts, 1876).

[3] William T. Hornaday, "The Extermination of the American Bison," *Report of the United States National Museum* for 1887 (Washington, D.C., 1889), pp. 376–548.

[4] J. F. H. Claiborne, *Mississippi as a Province, Territory, and State* (Jackson, 1880), p. 26n. Recent references to certain historic records of buffalo in Alabama and Florida are found in: Mark F. Boyd, "The Occurrence of the American Bison in Alabama and Florida," *Science*, Vol. 84 (1936), p. 203, "The Expedition of Marcos Delgado," *The Florida Historical Quarterly*, Vol. 16 (1937), pp. 2–32, "Diego Peña's Expedition," *ibid.*, Vol. 28 (1949), pp. 1–27; Irving A. Leonard, *Spanish Approach to Pensacola, 1689–1693* (Albuquerque, 1939), pp. 81–271 *passim*; John R. Swanton, "Notes on the occurrence of bison near the Gulf of Mexico," *Journal of Mammalogy*, Vol. 19 (1938), pp. 379–80, "Occurrence of Bison in Florida," *ibid.*, Vol. 22 (1941), p. 322, "The Indians of the Southeastern United States," *Bureau of American Ethnology*, Bulletin 137 (1946), pp. 324–28.

[5] E. Raymond Hall and Keith R. Kelson, *The Mammals of North America* (New York, 1959), map number 496, p. 1025.

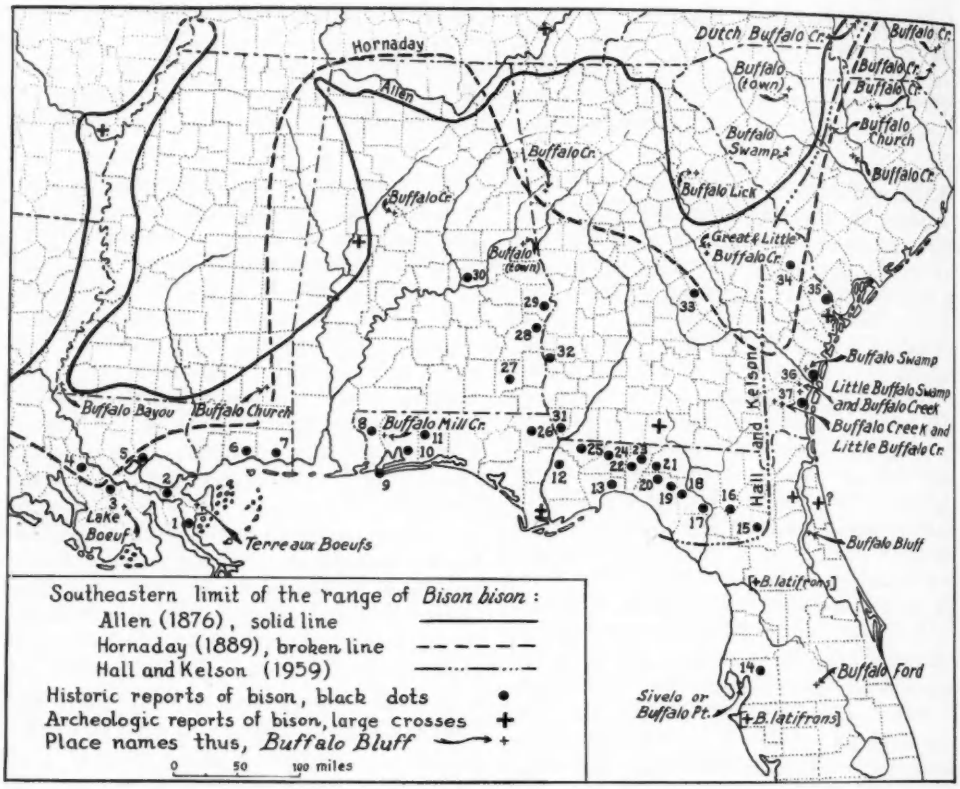

FIGURE 1

regions.[6] There are, in fact, many such records. About three dozen of the reports from beyond the Allen–Hornaday boundary are precise enough to be located with fair accuracy, and are shown on the accompanying map with black dots. The numbers below correspond to those on the map (Fig. 1); numbered paragraphs are grouped by sources:

1. Plaquemines Parish, Louisiana, March 3, 1699, Iberville: "Our men went hunting and found stags, deer, and buffaloes." In the same year and at about the same place the crew of the ship sent out by Daniel Coxe saw meadows on which "wild bulls and other beasts" were grazing.[7]

2. Near the site of New Orleans, March 6, 1699, Iberville: "A buffalo was killed . . . and . . . we saw three buffaloes on the bank."

3. At an Indian village, St. James Parish, March 15: "They brought us dried buffalo meat . . . and they break up the ground [in their cornfields] with buffalo bones."

4. Near Bayou Goula, Iberville Parish, March 17: "We saw buffalo and deer in the cane brakes . . . and [in the temples of the Indians] bundles of bison skins."[8] Bayou

[6] The denial has been perpetuated in the literature. Frank Gilbert Roe, for example, in what is no doubt one of the most widely read recent books on the buffalo, almost verbatim repeats the claim that there is no record of the historic bison in Alabama and Florida. *The North American Buffalo* (Toronto, 1951), p. 240.

[7] Pierre Le Moyne d'Iberville, "Historical Journal," in B. F. French, *Historical Collections of Louisiana and Florida*, Second Series (New York, 1875), p. 58; Daniel Coxe, "A Description of the English Province of Carolana," in B. F. French, *Historical Collections of Louisiana*, Part 2 (Philadelphia, 1850), p. 228.

[8] French, *Historical Collections of Louisiana and Florida, op. cit.*, pp. 61, 73–76.

Goula is within Hornaday's boundary but outside that of Allen.

5. Pass Manchac, between Lake Maurepas and Lake Pontchartrain, Louisiana, in 1712, Pénicaut: "We killed about fifteen buffaloes (*boeufs sauvages*) . . . and the following day we killed eight buffaloes and as many deer."[9]

6. Biloxi, Mississippi, 1699, Iberville: "Buffaloes were abundant."[10]

7. Near Pascagoula, Mississippi, 1698, Pénicaut: "They [the Indians] gave us bison meat . . . they had spoons of bison horn . . . and bison robes."

8. Northwest of Pensacola Bay, Florida, 1708: "The Frenchmen found a herd of bison."[11]

9. Santa Rosa Island, Santa Rosa County, Florida, 1693, Carlos de Sigüenza y Góngora: "Buffalo tracks were observed."

10. East Bay River, Santa Rosa County, 1693: "We found buffalo meat . . . buffalo skins . . . yarn of buffalo hair . . . ladles made of buffalo horn . . . and a large and frightful buffalo head that was still intact."

11. Okaloosa County, probably near Blackwater River, June 25, 1693, Laureano de Torres y Ayala: "Numerous buffalo tracks were found." In about the same place and the same year, Rodrigo de la Barreda: "A number of buffaloes were killed."

12. Between Apalachicola and Taluga rivers, near Bristol in Liberty County, Florida, Barreda, in journal of 1693, his comment referring to 1674: "The Indians went on hunting trips for buffalo, of which there is abundance."[12]

13. Fort San Marcos, Wakulla County, Florida, 1718, Barcia: "To support themselves the soldiers had to go out hunting buffalo (*cibolas*), which were plentiful."[13]

14. Northeast of Tampa Bay, 1772, Bernard Romans: "We found the footsteps of six or eight buffaloes, so plain as to be convinced of the tracks being made by those animals."[14] This comment is of special interest, for it indicates the most southerly position in Florida from which the historic bison has been reported. Allen knew of this record but dismissed it with the remark that it seemed "wholly improbable." It is conceivable that Romans may have mistaken the footprints of wild cattle for tracks of bison, but his report is surely not improbable. The prehistoric bison (*B. latifrons*, Fig. 1) ranged even farther south, as is shown by evidence found in Manatee County about 10 miles south of Tampa Bay.[15] This evidence, which was not yet known in Allen's time, does not prove the presence of *Bison bison*, but it may be noted that no physical barrier, lack of grazing land, or other geographical factor prevented the historic bison from wandering as far south as Tampa Bay; and the belief that this animal actually did reach this region and that the tracks seen by Romans really were made by bison is further supported by the fact that on maps of the eighteenth century the present Gadsden Point in Tampa Bay is labeled "Sivelo or Buffalo Point."[16] Allen himself, in discussing a "Buffalo Creek" in Georgia, says that in all other instances place names embodying the term buffalo have been found to have their origin in the former presence of the animal in the vicinity.[17]

15. Near Newman Lake, Alachua County, Florida, August 13, 1716, Diego Peña: "The Indians killed two buffalo (*sibolas*)."

16. Near Santa Fe River in the southern part of Columbia County, August 20: "Three buffalo were killed."

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[9] "Relation de Pénicaut," in Pierre Margry, *Découvertes et établissements des Français dans l'Ouest et dans le Sud de l'Amérique septentrionale, 1614–1754*, Vol. 5 (Paris, 1887), p. 497.

[10] French, *Historical Collections of Louisiana and Florida, op. cit.*, p. 49.

[11] Margry, *op cit.*, pp. 389–90, 480.

[12] Leonard, *op. cit.*, pp. 157, 161–62, 233, 267, 270.

[13] Andrés Gonzáles de Barcia Carballido y Zuñiga (pseud., Gabriel de Cárdenas z Cano), *Ensayo cronológico para la historia general de la Florida, 1512–1722* (Madrid, 1723), p. 338. See also, *Barcia's Chronological History*, translated by Anthony Kerrigan (Gainesville, 1959), p. 368.

[14] Bernard Romans, *A Concise Natural History of East and West Florida* (New York, 1775), p. 281.

[15] Morris F. Skinner and Ove C. Kaisen, "The Fossil Bison of Alaska and a Preliminary Revision of the Genus," *Bulletin of the American Museum of Natural History*, Vol. 89, No. 3 (1947), p. 208.

[16] Bernard Romans' Map of Florida 1774, in Atlas accompanying Philip Lee Phillips, "Notes on the Life and Works of Bernard Romans," *Publications of the Florida State Historical Society*, No. 2 (Deland, 1924); Map of East Florida in 1776, in Wilbur Henry Siebert, "Loyalists in East Florida 1774 to 1785," *ibid.*, No. 9 (1929), Vol. 1, opposite p. 44; William Faden, *The North American Atlas* (London, 1778), Plate 26.

[17] Allen, *op. cit.*, p. 225.

17. West of Suwannee River in southeastern Lafayette County, August 24: "There is much game, deer and buffalo, hereabouts. They killed two buffalo."

18. Northwestern corner of Lafayette County, August 25: "At this place there are many buffalo. Two were killed."

19. Northeastern corner of Taylor County, August 25: "There are many buffalo."

20. North-central Taylor County, August 27: "Two buffalo were killed. Many are the buffalo which have withdrawn to this region." Same place, August 28: "We killed two buffalo."

21. East of Aucilla River in the southeastern corner of Madison County, August 30: "Three buffalo were killed."

22. West-central Jefferson County, September 7: "Three buffalo were killed. The *çhicazas* [old abandoned farm fields] abound in cattle, especially buffalo."[18]

23. Mission San Lorenzo de Ivitachuco, west of Aucilla River in central Jefferson County, April 10, 1699, Letter from Don Patricio Hinachuba: contains references to "a hunt for buffalo (*civo, cibolo*)," and "Indians coming to sell their buffalo skins."[19] It is not clear from the letter how far from the mission the buffalo hunt took place, but it was no doubt somewhere in northern Florida.

24. Near Jackson Lake in northwestern Leon County, Florida, September 8, 1716, Peña: "Five buffalo were killed. On the prairie were seen more than three hundred cattle (*rezes*), buffalo (*sibolo*), and a few cows." On September 10 Peña crossed the Ochlocknee River from Leon County to Gadsden County "in a boat made from green buffalo hide."

25. Gadsden County near the Georgia line, September 12: "A buffalo was killed."[20]

26. West of Chipola River in Jackson County, Florida, in 1686, Marcos Delgado: "We began to encounter buffaloes (*cibolas*)."

27. Near Choctawatchie River in central Dale County, Alabama, 1686: "We observed many buffaloes."[21]

28. Northeastern Barbour County, Alabama, September 25, 1716, Peña: "We camped on a prairie belonging to some Christian Indians, having bountiful harvest of corn, beans, pumpkins . . . as well as buffalo."[22]

29. Kawita [Coweta], Creek Indian town on the Chattahoochee River in Russell County, Alabama, August 8, 1739, one of Oglethorpe's rangers: "The men [the Indians] hunt deer, turkeys, geese, buffaloes . . ."[23]

30. Taskigi, Creek Indian town in Elmore County, Alabama, ethnographic description of aboriginal conditions, no date: "They spent much time in hunting deer, turkeys, and bison."[24]

31. Indian village in Seminole County, Georgia, near the confluence of Flint and Chattahoochee rivers, September 13, 1716, Peña: "I made my abode on some benches carpeted with buffalo skins."

32. Just north of the site of Fort Gaines, Clay County, Georgia, September 24: "Six buffalo were killed."[25]

33. West of the Oconee River, Georgia, probably in Laurens County, July 31, 1739, one of Oglethorpe's rangers: "We killed two buffaloes, of which there are abundance, we seeing several herds of sixty or upwards in a herd."

34. Near the Ogeechee River, probably in Screven County, Georgia, 1739: "We killed several buffaloes, of which there is a great plenty."[26] The last position is within the boundary of Hornaday but outside the limits of Allen and Hall and Kelson.

35. Near Old Ebenezer, Effingham County, Georgia, 1734, Baron von Reck: "As to game,

[18] Boyd, "Diego Peña's Expedition," *op. cit.*, pp. 14–18.

[19] Mark F. Boyd, Hale G. Smith, and John W. Griffin, *Here They Once Stood* (Gainesville, 1951), p. 26.

[20] Boyd, "Diego Peña's Expedition," *op. cit.*, pp. 18–19.

[21] Boyd, "The Expedition of Marcos Delgado," *op. cit.*, p. 7.

[22] Boyd, "Diego Peña's Expedition," *op. cit.*, p. 22.

[23] N. D. Mereness, *Travels in the American Colonies* (New York, 1916), p. 221.

[24] Frank G. Speck, "The Creek Indians of Taskigi Town," *Memoirs of the American Anthropological Association*, Vol. 2, Part 2 (1907), p. 107.

[25] Boyd, "Diego Peña's Expedition," *op. cit.*, pp. 20–21.

[26] Mereness, *op. cit.*, p. 219.

here are turkies . . . stags . . . and buffaloes."[27]

36. Southern part of McIntosh County, Georgia, 1740's, Thomas Spalding: "Colonel William McIntosh . . . has often told me that he has seen ten thousand buffaloes in a herd between Darien and Sapelo River."[28]

37. Glynn County, Georgia, March 16, 1746, letter from General Oglethorpe: "Tomo-Chachi [Indian chief] and I at his desire go out tomorrow to hunt ye buffaloe." Glynn County, statement of Charles C. Jones, with reference to early nineteenth century: "Mr. James Hamilton Couper shot a wild buffalo early in the present century, near the headwaters of Turtle River, not very far from Brunswick, Georgia."[29]

RECORDS THAT ARE NOT LOCATED ON THE MAP

Some of the historical records are not geographically precise enough to be shown on the map but are nevertheless useful, for they help to confirm the presence of the bison in certain parts of the Southeast at certain times. About twenty reports of this type are included here.

Central Alabama, 1749, James Adair: "Our Chickasaw friends staid behind killing and cutting up buffalo . . . . The buffaloes are now become scarce as the Indians used to kill great numbers of them." Mobile River region, about 1700, Henri de Tonti: "Many animals are found here, such as bears, buffaloes, and deer."[30]

Piedmont of North Carolina, 1700, John Lawson: "This evening came down some Toteros [Tutelo Indians from the Yadkin] tall, likely men, having great plenty of Buffelos . . . . I have known some [buffalo] killed on the hilly part of Cape Fear River." John Brickell: "The Buffalo . . . its chiefest haunts being savannahs . . . there were two taken alive in the year 1730 near the Neuse River."[31]

Piedmont of South Carolina, 1722, Mark Catesby: "The Buffalo. They range in droves feeding in the open savannas morning and evening, and in the sultry time of the day they retire to shady rivulets and streams." James Glen, 1761: "The wild beasts are . . . Deer, Elk, Buffaloes." George Milligen-Johnston, 1770: "The buffaloes . . . are not near so numerous as they were a few years ago." Alexander Hewat, 1779, referring to the "early period" of South Carolina: "Herds of buffaloes were found grazing in the savannas."[32]

Piedmont of Georgia, between the Little and Broad rivers, 1774, William Bartram: "The buffalo, once so very numerous, is not at this day to be seen in this part of the country." In the same region, Bartram: [comment on] "heaps of white, gnawed bones of ancient buffaloe, elk, and deer." Southeastern Georgia, 1733, James Oglethorpe: "The wild beasts are deer, elk, bears, wolves, buffaloes." Francis Moore, 1735, description of St. Simons Island in Glynn County: "There are no buffaloes on it, though there are large herds upon the main." Benjamin Martyn,

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[27] Charles C. Jones, Jr., "The Dead Towns of Georgia," *Collections of the Georgia Historical Society*, Vol. 4 (1878), p. 14.

[28] Thomas Spalding, "Life of Oglethorpe," *ibid.*, Vol. 1 (1840), p. 268n.

[29] James Oglethorpe, "Letters," *ibid.*, Vol. 3 (1873), p. 20; Charles C. Jones, Jr., quoted in *South Carolina, Resources and Population, Institutions and Industries*, State Board of Agriculture (Charleston, 1883), p. 212n. The comment of Jones is cited in the volume as a "statement regarding the last buffalo known on the Atlantic coast," and it implies that stragglers of bison survived almost half a century after 1760, which is Hornaday's date for the extermination of the buffalo in upper Georgia.

[30] James Adair, *The History of the American Indians* (London, 1775), pp. 334–35, 415; Henri de Tonti, *Relation de la Louisiane* (Amsterdam, 1720), p. 11.

[31] John Lawson, *A New Voyage to Carolina* (London, 1709), pp. 48, 115; John Brickell, *The Natural History of North Carolina* (Dublin, 1737), pp. 107–8.

[32] Mark Catesby, *The Natural History of Carolina, Florida, and Bahama Islands* (London, 1731–1743), Vol. 2, p. XXVII; James A. Glen, "A Description of South Carolina" (London, 1761), in C. J. Milling, editor, *Colonial South Carolina* (Columbia, 1951), p. 76; George Milligen-Johnston, "A Short Description of the Province of South Carolina" (London, 1770), *ibid.*, p. 139; Alexander Hewat, "An Historical Account of the Rise and Progress of the Colonies of South Carolina" (London, 1779), in B. R. Carroll, *Historical Collections of South Carolina*, Vol. 1 (1836), p. 78. I have made no attempt to cite all of the buffalo records from the Piedmont of North Carolina and South Carolina, most of which fall well within the Allen–Hornaday boundary. Many reports from the early part of the eighteenth century are found in *The Colonial Records of North Carolina*, edited by William L. Saunders, 10 volumes (Raleigh, 1886–1890), *The State Records of North Carolina*, edited by Walter Clark, 13 volumes (Winston and Goldsboro, 1895–1905), and in *The Writings of Colonel William Byrd*, edited by John Spencer Bassett (New York, 1901).

1741: "There are in the province abundance of deer and buffaloes." Edward Kimber, in a description of Oglethorpe's march through southeastern Georgia and northeastern Florida in 1743, makes several references to moccasins of buffalo skin and other uses of buffalo hide.[33]

Western Florida, 1689, Andrés de Pez: "Many buffaloes, deer, and wild turkeys are found generally throughout the entire region." Peninsular Florida, 1675, Bishop Calderón: "They [the Indians] enter the forest in pursuit of bears, bisons (*cibolas*), and lions." Martin de Echagaray, 1684: "The country abounds in cattle of various kinds, including one variety which produces as good wool as that gotten from a sheep's back." William Stork, about 1775: "The buffalo is found in the savannahs, or natural meadows, in the interior of East Florida." William Bartram, 1773: "Buffiloe. . . this creature is become scare in East Florida, yet there remain a few in the Point [the peninsula]."[34]

THE SIXTEENTH CENTURY

The reports of Calderón, 1675, and Barreda, 1674, both from Florida, are the oldest clear historic records of the bison in the Southeast. So far as I know, none of the published records of the period before 1674, with two possibly valid exceptions, contain any reference to living bison occurring southeast of the Allen–Hornaday boundary. The exceptions are the reports of Fontaneda and Le Challeux.

Fontaneda was shipwrecked on the Florida coast some time in the middle of the sixteenth century and lived among the Indians for fifteen or twenty years. In his memoir, written in Spain about 1575, he claims to have spent two years among the Apalachee in the Tallahassee region, and he says of them that they eat "deer, foxes, woolly cattle (*vacas lanudas*), and many other animals." Buckingham Smith, the translator, construes *vacas lanudas* to mean bison—and it is hard to see what other meaning the term could have. But Fontaneda's account of the Apalachee is perhaps not to be trusted entirely, for it may have been based on nothing better than hearsay: both Buckingham Smith and John R. Swanton doubt that Fontaneda ever visited that people. Furthermore, it is not quite certain that the description of the Apalachee was the work of Fontaneda, for it was written on a separate sheet serving as cover for the manuscript. The manuscript bears his signature but the loose sheet does not. Still, whether or not Fontaneda was the author and regardless of hearsay, *someone*, in a piece of writing from the sixteenth century, made a reference to woolly cattle in Florida.[35]

A group of Frenchmen retreating in September, 1565, from the Spanish attack on Fort Caroline in northeastern Florida saw an animal that was described by Nicolas Le Challeux as "a great beast like a deer, which had a very big head, flaming and staring eyes, pendant ears, and a humped back (*une grande beste comme un cerf, qui avoit la teste fort grosse, les yeux flamboyans et sans silles, les oreilles pendantes, ayant les parties de derrière éminentes*)." The passage has been variously interpreted. Professor Wyman believed that the animal could have been no other than a bison, whereas Allen thought that the beast described, if not actually a deer,

[33] William Bartram, *The Travels of William Bartram*, Naturalists Edition, edited by Francis Harper (New Haven, 1958), pp. 30, 204; James Oglethorpe, "A New and Accurate Account of the Provinces of South Carolina and Georgia" (London, 1733), in *Collections of the Georgia Historical Society*, Vol. 1 (1840), p. 51; Francis Moore, "A Voyage to Georgia" (London, 1744), *ibid.*, 117, 122; Benjamin Martyn, "An Impartial Inquiry into the State and Utility of the Province of Georgia" (London, 1741), *ibid.*, p. 183; Edward Kimber, *A Relation or Journal of A Late Expedition to the Gates of St. Augustine on Florida* (London, 1744, reprinted Boston, 1935), pp. 13, 16, 18.

[34] Andrés de Pez, "Memorial," in Leonard, *op. cit.*, p. 81; Lucy C. Wenhold, translator, "A 17th century letter of Gabriel Díaz Vara Calderón, Bishop of Cuba, describing the Indians and Indian Missions of Florida," *Smithsonian Miscellaneous Collection*, Vol. 95, No. 16 (1936), p. 13, and Plate 10; Martin de Echagaray, in William Edward Dunn, *Spanish and French Rivalry in the Gulf Region of the United States 1678–1702*, University of Texas Bulletin No. 1705 (1917), p. 23; William Stork, *A Description of East Florida* (London, 1769), p. 19; William Bartram, "Travels in Georgia and Florida 1773–74. A Report to Dr. John Fothergill," annotated by Francis Harper, *Transactions of the American Philosophical Society*, New Series, Vol. 33, Part 2 (1943), p. 164.

[35] *Memoir of Do. d'Escalante Fontaneda Respecting Florida*. Written in Spain about the year 1575, translated by Buckingham Smith (Washington, D.C., 1854, reprinted Miami, 1944), pp. 24, 62n, 77; Swanton, "The Indians of the Southeastern United States," *op. cit.*, p. 90.

"must have been a creation of the excited imagination."[36]

It is impossible to decide whether or not the comments of Fontaneda and Le Challeux, considered by themselves, are valid references to the bison, but their validity becomes plausible if they are viewed in the context of the whole historic record. In the Southeast, more particularly in the interior of the Southeast where buffalo might be expected, the history of that record can be divided into three parts. There is a late period after 1674, which has the distinction of having yielded all of the clear records of the buffalo that have come to light. There is an early period, the time of the expeditions of Hernando de Soto in the 1540's, Tristan de Luna in the 1550's, and Juan Pardo in the 1560's, a period which provides many good reports on landscape features, plants, and animals, but not a single record of the observation of living bison. And there is a middle period, which may be called the silent one, for after Pardo's departure in 1567 we have no more eyewitness reports from the inner Southeast until the 1670's, when James Needham, Henry Woodward, and other English travelers coming from the north and the east began to explore the interior, when the Spaniards were moving up from Florida to reestablish their contact with the Upper Creeks in east-central Alabama, and when, shortly, the French were to come down the Mississippi to settle Louisiana.[37] Gallatin, Allen, and other scholars long ago reached the conclusion that there were no buffaloes in the Southeast in the sixteenth century. The conclusion is convincing, for the assumption that the writers of the four separate De Soto narratives, the four Pardo accounts, and the numerous letters in the De Luna papers would all have failed to make some remark on the bison, had it been observed, is incredible; and it is almost as hard to believe that the armies of these expeditions, marching up and down the country for several years and sending out numerous scouting parties, could have missed seeing the animal if it had been there in any considerable numbers. But about a century later the bison was observed all over the Southeast, and it must be assumed that a major migration and extension of the range had taken place during the silent period.[38] We have no record of when the first historic bison reached Alabama, Georgia, or Florida, but it is possible, for all we know, that small unobserved groups or individual forerunners of the larger herds to come were on the move in the Southeast as early as De Soto's time or shortly thereafter. And it seems reasonable to think that among these early arrivals were the *vacas lanudas* of Fontaneda and the *grande beste* of Le Challeux.

ARCHEOLOGICAL RECORDS

The archeological evidence of the historic bison in the Southeast is not abundant, but that which has been found supports the historical record on two main points, namely, the late arrival of the species in the region, and its advance well beyond the traditional geographical limits shown on the map. The late

[36] Nicolas Le Challeux, "Histoire mémorable du dernier voyage en Floride," in Paul Gaffarel, *Histoire de la Floride Française* (Paris, 1875), p. 470; Jeffries Wyman, "Fresh-Water Shell Mounds of the St. John River, Florida," *Peabody Academy of Science*, Fourth Memoir (1875), p. 80; Allen, *op. cit.*, p. 98.

[37] One of the first English references, perhaps the very first, to bison in the Southeast—or at least a very probable reference to bison—is found in Abraham Wood's description of the journey in 1673 of James Needham and Gabriel Arthur to the Indian villages in the Tennessee Valley, where, we are informed, "many hornes like bull hornes lye upon their dunghills." See "Letter of Abraham Wood to John Richards," in Clarence Walworth Alvord and Lee Bidgood, *The First Explorations of the Trans-Allegheny Region by the Virginians* (Cleveland, 1912), p. 213.

[38] The narratives of the De Soto expedition imply that the bison, if not actually present in the Tennessee River valley in the sixteenth century, was found not very far to the north or northwest of that river. Hence, the migration during the silent period may have shifted the margin of the range from Tennessee to northern Florida, or about 400 miles in one hundred years. Such a rate of advance is probably not unusual. According to E. Raymond Hall mammals are known to have extended their ranges by 200 miles in the past forty years. See *Zoogeography*, edited by Carl L. Hubbs, Publication No. 51 of the American Association for the Advancement of Science (Washington, D.C., 1958), p. 373. N. S. Shaler's investigations in the Ohio Valley led him to the conclusion that the first appearance of the bison east of the Mississippi River "was like an irruption in its suddenness." In Allen, *op. cit.*, Appendix, p. 233. The evidence from the Southeast clearly does not support Skinner and Kaisen in their assertain that "the bison population was not spreading in the period preceding the discovery of America." *Op. cit.*, p. 131. At any rate, it certainly was spreading in the Southeast during the seventeenth century.

arrival is suggested by the fact that no trace of this animal has ever been detected in the earlier archeological horizons of the Southeast. All of the bison remains discovered so far have come from sites known to be recent or which suggest recency. I am not aware of any radiocarbon dates derived from bison relics in this area, and it may well be that any such relics are too recent for worth-while dating by this method. The consensus of archeologists, I suspect, would be that no buffalo bone found in the Southeast is likely to be more than three hundred years old, possibly four hundred.

The advance of the species beyond the Allen–Hornaday and Hall–Kelson boundaries is indicated by the positions of the archeological finds, shown on the maps with large crosses (Fig. 1). Some of the first discoveries were reported by Clarence B. Moore about fifty years ago. A gorget or pendant seven inches long, made from the femur of a bison according to the identification by Professor F. A. Lucas of the United States National Museum, was excavated near the surface of a mound situated about a mile west of Apalachicola in Franklin County, Florida. Strips of bison horn, also identified by Lucas, were found at a depth of about four feet in a mound near Moundville a few miles east of the Black Warrior River in Hale County, Alabama. Parts of the right humerus and the right radius of a bull buffalo were discovered at a depth of less than two feet in the Menard Mound, Arkansas County, Arkansas, and in a field adjacent to the mound "many bison bones" were observed. Moore has also reported a jaw, "probably of a young bison," dug out of a shallow gravel pit in Hamilton County, Tennessee. This locality is well within the Allen–Hornaday boundary.[39]

In his "Antiquities of the Southern Indians," Charles C. Jones makes brief mention of animal remains found in Georgia shellheaps, including buffalo bones, but he does not locate the sites. In another publication he is more exact: "I have seen the skull of a buffalo, with the horns still attached, in good state of preservation, which was ploughed up in a field in Brooks County, Georgia." The county borders on Florida in the south-central part of Georgia, and the incident occurred in the middle part of the nineteenth century; so perhaps the skull dates from the eighteenth.[40]

A report from the Irene Mound in Chatham County, Georgia, lists eleven species of mammals represented among the faunal remains, including perhaps *Bison bison*; uncertainty about the bison is indicated by a question mark. The authors "guess" that this site was occupied until about 1600 A.D.[41]

What appear to be conflicting, or at any rate confusing, reports come from the excavation in Castillo de San Marcos, St. Augustine, Florida. Hale G. Smith says that the collection contains a scapula of a large animal, "probably a buffalo," but J. C. Harrington and co-authors, in reporting on the excavation, make no mention of bison bones. The Castillo de San Marcos was built in the 1670's.[42]

A part of a bison humerus found in the excavation of Fort Pupo in Clay County, Florida, about three miles south of Green Cove Springs, is reported by John M. Goggin. The identification was made by H. B. Sherman of the University of Florida, who adds that four carpal bones of the bison from the same site have also been identified. Fort Pupo, according to Goggin, was built shortly after 1716 and was demolished in 1740.[43]

The scarcity of archeological reports does

[39] Clarence B. Moore, "Certain Aboriginal Remains of the Northwest Florida Coast, Second Part," *Journal of the Academy of Natural Sciences of Philadelphia*, Second Series, Vol. 12, Part 1 (1903), p. 225; "Certain Aboriginal Remains of the Black Warrior River," *ibid.*, Vol. 13 (1905), pp. 162–63; "Certain Mounds of Arkansas and Mississippi," *ibid.*, Vol. 13 (1908), p. 492; "Aboriginal Sites on Tennessee River," *ibid.*, Vol. 16 (1915), p. 368.

[40] Charles C. Jones, Jr., *Antiquities of the Southern Indians* (New York, 1873), pp. 200, 301. *Idem*, quoted in *South Carolina, Resources and Population, Institutions and Industries*, State Board of Agriculture (Charleston, 1883), p. 212n.

[41] J. Caldwell and C. McCann, *Irene Mound Site* (Athens, 1941), pp. 73, 78.

[42] Hale G. Smith, "The European and the Indian," *Florida Anthropological Society Publications*, No. 4 (1956), p. 72; J. C. Harrington, Albert C. Manucy, and John M. Goggin, "Archeological Excavations in the Courtyard of Castillo de San Marcos, St. Augustine, Florida," *The Florida Historical Quarterly*, Vol. 34 (1955), pp. 99–141.

[43] John M. Goggin, "Fort Pupo: A Spanish Frontier Outpost," *ibid.*, Vol. 30 (1951), p. 176; H. B. Sherman, "The Occurrence of Bison in Florida," *The Quarterly Journal of the Florida Academy of Sciences*, Vol. 17 (1954), pp. 229, 231.

not prove, I believe, that the bison was scarce. The buffalo population in the Southeast must have been fairly large at its peak, which was reached perhaps about 1700 A.D. By 1750 it was certainly declining. It is not unusual to find the bison described in the early narratives as abundant, plentiful, very numerous; rather large herds were observed, even herds of ten thousand animals—if we can trust the memory of Colonel McIntosh—and buffalo hides, although never so important a trade item as deer skins, were once exported.[44] Clarence Moore says he saw "many bison bones" lying about in a field, and Bartram speaks of having seen "heaps" of them. The old records do not tell us what became of all the bones, but it may be surmised that there are several reasons for the scarcity of reported finds. For one thing, it is not improbable that some bison relics in archeological sites may have been overlooked or simply have not been reported, for the current practice of having faunal remains identified by experts has not always been common in the past. Second, I suspect that the plowing up of a skull in Brooks County, Georgia, noted by C. C. Jones, is unique only in that an account of the incident happens to have found its way into print; similar but unrecorded finds must have been made on other farms during the last couple of centuries. Furthermore, it may be that in the Southeast, as in the Great Plains, most of the buffalo bones that turned up were gathered and made into fertilizer long before the archeologists began their explorations.

PLACE NAMES

Place names provide additional confirmation of the late arrival of the bison in the Southeast. There is no evidence that toponyms with the word buffalo in them are very old in this region. French terms like Terre aux Boeufs, not uncommon in Louisiana, can not have originated much before 1700, and, with the exception of Sivelo Point in Tampa Bay, the Southeast seems not to have any place names in which Spanish words for the buffalo occur, or if such names ever existed they have not survived. Most common are the names in English, Buffalo Creek, Buffalo Swamp, Buffalo Ford, and the like, some of which may have come into use as early as 1670 or 1680 with the entry of the first English traders, the anonymous contemporaries of James Needham and Henry Woodward.[45] None of these buffalo names, whether French or English, is known to be of Indian origin. Southern toponymic studies, primarily those of William A. Read, have shown that Indian place names commonly embody words for animals, for example, *Chilatchee*, Fox River, *Sawaklahatchee*, Raccoon Creek, *Isawaya*, Crouching Deer; and there are names formed with the words for alligator, panther, turkey, turtle, and others. But no Indian place name with a term for the buffalo has been reported.[46] The languages of the Indians in the Southeast do not lack words for this animal: in Choctaw, of Muskhogean linguistic stock, the term for buffalo is *yannash*; in Biloxi, a Siouan language, it is *yinisa*; in Atakapa, of

[44] In Abbeville County, Georgia, "Henry Fowler, a pioneer settler counted one hundred buffaloes grazing at one time on a single acre of ground." *South Carolina, Resources and Population, Institutions and Industries*, State Board of Agriculture (Charleston, 1883), p. 146. Buffalo skins are listed among the exports in *Records in the British Public Records Office Relative to South Carolina 1701–1710*, indexed by Alexander S. Salley (facsimile reproduction, Columbia, 1947), Vol. 5, p. 204. Trade in "Buffe and Deere skinnes" in North Carolina is reported as early as 1584 in Henry S. Burrage, "Captain Arthur Barlowe's Narrative," *Early English and French Voyages* (New York, 1906), p. 232.

[45] The oldest record of the naming of a Buffalo Creek that has come to my attention is found in William Byrd's journal of October 7, 1728. *Op. cit.*, p. 127; also *Colonial Records of North Carolina*, Vol. 2 (1886), p. 790.

[46] William A. Read, "Louisiana Place Names of Indian Origin," *University Bulletin, Louisiana State College*, N. S., Vol. 19 (1927), No. 2; "Florida Place Names of Indian Origin and Seminole Personal Names," *Louisiana State University Studies*, 11 (1934); "Indian Place Names in Alabama," *ibid.*, 29 (1937); "Indian Stream Names in Georgia," *International Journal of American Linguistics*, Vol. 15 (1949), pp. 128–32. See also M. M. Nelson, "Folk Etymology in Alabama Place Names," *Southern Folklore Quarterly*, Vol. 14 (1950), pp. 193–214; V. P. Brown and J. P. Nabes, "The Origin of Certain Place Names in Jefferson County, Alabama," *The Alabama Review*, Vol. 5 (1952), pp. 177–202; E. W. McMullen, *English Topographic Terms in Florida, 1563–1874* (Gainesville, 1953); J. Clarence Simpson, "A Provisional Gazetteer of Florida Place-Names of Indian Derivation," edited by Mark F. Boyd, *Florida Geological Survey*, Special Publication No. 1 (1956).

Tunican stock, it is *coko'n*.[47] The southeastern tribes presumably have a word for the buffalo because they once came from buffalo country in the West, and they are known to have come in rather recent prehistoric time.[48] But the coming of the bison to the Southeast must have been even more recent, for the absence of buffalo terms from Indian place names in this region can only be explained, I think, by the assumption that the buffalo itself was absent when these tribes arrived.

Place names not only confirm the late arrival of the bison but are an aid in tracing the limit of the maximum range. A name like Buffalo Creek or Buffalo Ford is perhaps not in itself proof that the bison once inhabited the neighborhood in which the name occurs, but such names are certainly good clues, which usually have been found to lead to actual records, personal memories, or folk traditions of the former presence of the buffalo.[49]

The evidence provided by the clues is naturally strengthened if it agrees with the historical and archeological records, as it does in the Southeast. At least sixty place names containing the word buffalo exist or have existed in the region comprising North Carolina, South Carolina, Georgia, Florida, Alabama, and the southernmost parts of Mississippi and Louisiana; and of these names twenty are found beyond the Hall–Kelson boundary, twenty-five outside the Hornaday limit, and about thirty-five beyond the limit drawn by Allen.[50] The positions of these place names imply that the bison range extended to a distance of 60 miles east of the Hornaday and Hall–Kelson boundaries in North Carolina, and 30 miles east of them in South Carolina, or, expressed differently, to a line about 80 or 90 miles from the Atlantic coast in the two states; to the coast of Georgia; to a distance of from 100 to 125 miles south of the Hall–Kelson delimitation in peninsular Florida; and, coinciding with the Hall–Kelson boundary, to the Gulf coast in western Florida, Alabama, Mississippi, and Louisiana.

Most of the buffalo place names are found on the topographic quadrangles of the United State Geological Survey.[51] But some of them,

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[47] Cyrus Byington, "A Dictionary of the Choctaw Language," edited by John R. Swanton and Henry S. Halbert, *Bureau of American Ethnology*, Bulletin 46 (Washington, D.C., 1915), pp. 372, 402; James Owen Dorsey and John R. Swanton, "A Dictionary of the Biloxi and Ofo Languages," *ibid.*, 47 (1912), pp. 293, 299; Albert S. Gatschet and John R. Swanton, "A Dictionary of the Atakapa Language," *ibid.*, 108 (1932), pp. 162, 163.

[48] Swanton, "The Indians of the Southeastern United States," *op cit.*, pp. 21–33. On Indian tradition of arrival before the bison, *idem*, "Social Organization and Social Usages of the Indians of the Creek Confederacy," *Bureau of American Ethnology*, Annual Report, Vol. 42 (Washington, D.C., 1928), p. 527. For archeological evidence of the recent coming of the bison to the Ohio Valley, see N. S. Shaler, in Allen, *op. cit.*, pp. 232–36; to central Tennessee, see William Edward Myer, "Prehistoric Villages in Middle Tennessee," *Bureau of American Ethnology*, Annual Report, Vol. 41 (Washington, D.C., 1928), pp. 609–11.

[49] Terre aux Boeufs "was named for the large number of buffaloes that spent the winter there." Gordon Gunter, "Remarks on American Bison in Louisiana," *Journal of Mammalogy*, Vol. 24 (1943), p. 398. Buffalo, Union County, South Carolina, "takes its name from nearby Buffalo Lick Springs, frequented according to tradition by herds of buffaloes in the early days." *Palmetto Place Names* (Columbia, 1941), p. 29. "Buffalo Church in Cherokee County, South Carolina got its name from Buffalo Creek, which got its name because buffaloes roamed the area in early days." *Letter*, January 1960, from Mr. John C. Fowler, Postmaster, Gaffney, S.C. For similar traditions, see Hornaday, *op. cit.*, p. 379; Douglas L. Rights, "The Buffalo in North Carolina," *The North Carolina Historical Review*, Vol. 9 (1932), p. 244; Henry Gannett, *American Names, A Guide to the Origin of Place Names in the United States* (Washington, D.C., 1947), p. 60. Not all buffalo names are directly derived from the bison: "Buffalo City in Dare County, North Carolina was named after a company from the city of Buffalo, New York that came and logged the place about eighty years ago." *Letter*, January 1960, from Mrs. Minnie L. Spruill, Postmaster, East Lake, N.C.

[50] In the northern part of North Carolina, not shown in Fig. 1 because it extends outside the margin of the map, the Allen boundary departs westward by about 100 miles from the Hornaday and Hall–Kelson limits, and for that reason Allen excludes more buffalo place names than do the others.

[51] Bayou Terre aux Boeufs, St. Bernard and Plaquemines parishes, Shell Beach and St. Bernard quadrangles, La.
Lake Boeuf, La Fourche Parish, Lac Des Allemands quadrangle, La.
Buffalo Bayou (River), Wilkinson County, Woodville quadrangle, Miss.
Buffalo Church, Green County, Beaumont quadrangle, Miss.
Buffalo Creek, Tuscaloosa County, Yolande quadrangle, Ala.
Buffalo, Chambers County, Opelika quadrangle, Ala.
Buffalo Mill Creek, Santa Rosa County, Milton and Muscogee quadrangle, Fla.
Buffalo Bluff, Putnam County, Palatka quadrangle, Fla.

which apparently have dropped out of use and have disappeared from the map, can only be documented by historical reference. Among these place names are the following:

Sivelo Point or Buffalo Point, Tampa Bay, Florida. As has already been noted, this name appears on Bernard Romans' Map of Florida 1774, and on other early maps (note 16).

Buffalo Ford, Polk County, Florida. Mention is made of this place in Lieutenant Robert C. Buchanan's journal of 1837 and 1838. Having marched 12 miles in an easterly direction from Fort Fraser, which was situated near Lake Hancock a few miles northeast of the site of Bartow, Buchanan's company "halted for the night at Buffalo Ford," and after crossing the ford the next day continued the march in the same general direction for 17 miles to the Kissimmee River.[52]

Buffalo Post Office, Carroll County, northwestern Georgia.[53] Like Buffalo Creek in the same county, the post office was situated just inside the Hornaday boundary but outside that of Allen.

Buffalo Lick, Oglethorpe County, northeastern Georgia. The lick is well inside the Allen and Hornaday limits but deserves passing mention, for it is probably the best-known buffalo place in the Southeast. It appeared on maps as early as 1770, was visited and described by Bartram in 1773, and is mentioned in most recent guide books and gazetteers.[54]

"Buffalo wallow." In the southeastern corner of Randolph County, central North Carolina, about 30 miles east of the Hornaday and Hall–Kelson boundaries, the site of a former buffalo wallow is reported to be known to local people.[55] The name is not a topographic term in the usual sense but refers to a spot visited by buffaloes in the early days.

Buffalo Race-Path, Granville County, north-central North Carolina. This place is also some 30 miles east of the Hornaday and Hall–Kelson limits. The Laws of North Carolina, 1764, inform us that court for the County of Bute, now part of Granville County, was to be held quarterly "at a Place known by the name of Buffalo Race-Path."[56]

CONCLUSIONS AND HYPOTHESIS

Reports of historic, archeologic, and toponymic studies jointly support the following conclusions: (1) In 1500 A.D. the buffalo (*Bison bison*) had not yet entered the Southeast, (2) a migration into the region began after the middle of the sixteenth century and reached its greatest geographic extent by about 1700 A.D., and (3) the bison range at its maximum extended to the Gulf coast of Louisiana, Mississippi, Alabama, and western Florida, to the latitude of Tampa Bay in peninsular Florida, to the coast of Georgia, and to a line 80 or 90 miles from the coast in South Carolina and North Carolina. The delimitation is not regarded as definitive, for new evidence may turn up and show that the range actually extended even farther east in North Carolina and South Carolina and farther south in Florida.

Buffalo Creek, Little Buffalo Creek, Brantley County, Nahunta quadrangle, Ga.

Buffalo Swamp, Little Buffalo Swamp, Buffalo Creek, Little Buffalo Creek, Glynn County, Hortense, Bladen, and Everett City quadrangles, Ga.

Buffalo Swamp, McIntosh County, Everett City quadrangle, Ga.

Little Buffalo Creek, Hancock County, Milledgeville quadrangle, Ga.

Great Buffalo Creek, Washington County, appears as Buffalo Creek on the Index to Topographic Maps, Georgia.

Buffalo Creek, Carroll County, Tallapoosa quadrangle, Ga.

Buffalo Creek, Richland County, Killian and Messers Pond quadrangles, S.C.

Buffalo Church, Fairfield County, Columbia quadrangle, S.C.

Buffalo Creek, Kershaw County, Index to Topographic Maps, S.C.

Buffalo Creek, Hoke County, Southern Pines and Laurinburg quadrangles, N.C.

Buffalo Creek, Harnett and Hoke counties, Clifdale quadrangle, N.C.

Buffalo Creek, Little Buffalo Creek, Johnston County, Kenly quadrangle, N.C.

Buffalo Creek, Durham County, Durham North quadrangle, N.C.

[52] Robert C. Buchanan, "A Journal of Lt. Robert C. Buchanan During the First Seminole War," edited by Frank F. White, Jr., *The Florida Historical Quarterly*, Vol. 29 (1950), pp. 134–35.

[53] Adiel Sherwood, *A Gazetteer of Georgia*, Fourth Edition (Atlanta, 1860), p. 198.

[54] Purcell Map, 1770, in John R. Swanton, "Early History of the Creek Indians and their Neighbors," *Bureau of American Ethnology*, Bulletin 73 (Washington, D.C., 1922), Plate 7; Bartram, "Travels in Georgia and Florida," *op. cit.*, p. 140.

[55] Douglas L. Rights, *op. cit.*, p. 249.

[56] Laws of North Carolina, 1764, Chapter XIV, Article XVI, in *The State Records of North Carolina*, Vol. 23 (1904), p. 625.

The reason for the disappearance of the bison from the Southeast has best been explained, I think, by Allen: "Most writers . . . speak of it [the buffalo] as having been 'driven out' by the encroachment of settlements. While a few of the herds may have migrated westward, it seems more probable that it was *exterminated* rather than *driven out*."[57] So far as I know, the historic reports from the Southeast provide no evidence of a general westward trek of the buffalo, but many of the early narratives do inform us that the animal was heavily hunted, killed in great numbers, extirpated, and a few exact records of the killing of the last herds are known.[58]

The most interesting problem, because it remains unsolved, is not the disappearance of the bison but the reason for its appearance in the Southeast, a problem in which the effect of human activity is one of the factors. I suggest the idea that man played as significant a role in the coming as in the going of the bison. The idea rests on the two assumptions that the buffalo invasion could not have succeeded unless suitable food in adequate amount was available and, second, unless the hunting pressure exerted by man, the bison's greatest enemy who in the end killed him, was sufficiently light or eased to permit the animal to breed and establish itself in the new habitat.

The historical sources contain very little precise information on the food of the bison in the Southeast, but the evidence that does exist seems to indicate that in this region, as in the Great Plains, the buffalo was mainly a grazing and not a browsing animal. Browsing is perhaps not out of the question in the southeastern woodlands, but there is no proof of it in the old records. The herds of buffalo are commonly described as "feeding," "pasturing," or "grazing" in open savannas, prairies, meadows, or old fields, but just what they were feeding on is usually not explained.[59] However, the food of the buffalo in the West is known. The Plains bison, according to Hornaday, utilized many grasses, the most important of which belong to eight genera, and six of these genera, including more than fifty species, are listed by J. K. Small as native in one part or another of the Southeast, while only two genera are absent.[60] There was suitable grass for the bison in the Southeast, and that it was abundant is shown by the fact that in the 1850's nearly six million head of cattle, sheep, horses, and mules in South Carolina, Georgia, Florida, Alabama, and Mississippi were supported almost entirely by grazing on the open range.[61]

The habitats of the southern grasses listed by Small fall into three principal categories: swamps and wet places, pine lands, and open country such as meadows, prairies, fields, and waste places. The last two categories are most relevant to the argument, for the character of the pine lands and the very existence of much of the open country are results of human activity. In a previous study of historical records I came to the conclusion, based primarily on comments in early narra-

[57] Allen, *op. cit.*, p. 117. Claiborne refers to a Choctaw tradition according to which the bison, because of a great drought in the early part of the eighteenth century, migrated to the country west of the Mississippi River and never returned. *Op. cit.*, p. 484. The tradition cannot be accepted as an explanation of the final disappearance, for the bison was seen in many parts of the Southeast long after the early eighteenth century.

[58] The last herd of buffalo in Pennsylvania, about 350 animals, was destroyed between Christmas and New Years 1799 in Union County. Henry W. Shoemaker, *A Pennsylvania Bison Hunt* (Middleburg, 1915), pp. 28–37. James Mooney says that the last bison in Ohio were killed in Jackson County in 1800. "Myths of the Cherokees," *Bureau of American Ethnology*, Annual Report, Vol. 19, Part 1 (Washington, D.C., 1900), p. 447. In Louisiana the last buffalo was killed near Monroe, Ouachita County, in 1803. Gunter, *op. cit.*, p. 339. See also statement of Charles C. Jones concerning the last bison shot in Georgia (note 29). The records suggest that the bison survived in the East somewhat longer than is indicated by Hornaday on his map.

[59] To my knowledge, the only plant named in the early bison literature of the Southeast that can be specifically identified is buffalo clover (*Trifolium reflexum*), a Piedmont species "not much coveted by any cattle but the Buffalow." Note in Governor Tryon's journal of 1767, *Colonial Records of North Carolina*, Vol. 7 (1890), p. 1007. See also comment in Stephen Elliott, *A Sketch of the Botany of South-Carolina and Georgia*, Vol. 2 (Charleston, 1824), p. 202.

[60] The eight genera are: *Bouteloua*, grama, *Buchloë*, buffalograss, *Stipa*, needlegrass, *Aristida*, wiregrass, *Koeleria*, Junegrass, *Poa*, bluegrass, *Festuca*, fescue, and *Andropogon*, bluestem. Hornaday, *op. cit.*, pp. 426–29. Absent from the Southeast are *Buchloë* and *Koeleria*. John Kunkel Small, *Flora of the Southern United States* (New York, 1903), pp. 60–156 *passim*.

[61] Frank L. Owsley, "The Pattern of Migration and Settlement on the Southern Frontier," *The Journal of Southern History*, Vol. 11 (1945), pp. 162–64.

tives and the opinions of foresters of today, that the open, parklike appearance of the southern pine forest with its lack of dense underbrush and its floor carpeted with grass — the "open airy grove" of Bartram — was caused by the practice of burning the woods at frequent intervals, first by the Indians and later by the American pioneer settlers; and that much, but not necessarily all, of the open country variously described in the old reports as savanna, prairie, meadow, or old field was in fact former forest land that had been cleared for farming by the Indians and later abandoned.[62] And the grasses, the members of "the campestrian flora," as Charles Mohr observed in Alabama, "have spread . . . wherever the forest has been removed."[63] Aboriginal deforestation and the custom of burning the woods, practiced no doubt for many centuries before 1500 A.D., favored the spread and increase of the grasses, and we can therefore say that the buffalo pastures of the Southeast were in large measure made by man. Unlike Shaler, however, I do not believe that the pastures were *intended* for the buffalo, but they made his coming possible.[64]

To reach these pastures the bison had to invade a region held in the sixteenth century by an Indian population which from all accounts, historical and archeological, was both large and well organized into powerful tribes; and whether or not the invader could have successfully run the gantlet of these tribes in their prime we can never know, for the test was never made: when the bison herds came in force during the seventeenth century the Indian population had become seriously depleted. By comparing the number and distribution of prehistoric sites and the Indian settlements described in the chronicles of the De Soto expedition with the descriptions dating from the late seventeenth century and the early eighteenth, archeologists and anthropologists have reached the conclusion that a great population decline occurred between 1540 and 1700 A.D., and that large sections of the Southeast became virtually depopulated.[65] It is estimated that in some regions during that time the population was reduced by as much as 80 percent.[66] As a result the hunting pressure was also reduced, and the lands abandoned by man, the old fields and deserted croplands, the *chicazas* of Diego Peña, became more accessible to the buffalo.

In short, man helped to prepare and man abandoned an ecological niche suitable for the bison. The incursion of this animal into the Southeast was not just an episode in zoogeographical history, for it was contingent upon the work of man and the accidents in human history.

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[62] On conversion of woodland to prairie, see especially Michael Tuomey, *First Biennial Report on the Geology of Alabama* (Tuscaloosa, 1850), p. 137. On the effect of burning the woods at frequent intervals, see particularly Roland M. Harper, "Forests of Alabama," *Geological Survey of Alabama*, Monograph 10 (University, Alabama, 1943), pp. 33–34. For further documentation of evidence supporting the conclusion, see Erhard Rostlund, "The Myth of a Natural Prairie Belt in Alabama: An Interpretation of Historical Records," *Annals*, Association of American Geographers, Vol. 47 (1957), pp. 392–411.

[63] Charles Mohr, "Plant Life of Alabama," *Geological Survey of Alabama*, Monograph No. 5 (Montgomery, 1901), pp. 99–104.

[64] N. S. Shaler, in accounting for the extension of the buffalo range into Ohio, Kentucky, and Tennessee, assumes that the Indians deliberately converted forest to prairie by means of fire *in order* to provide more grazing land for the bison. *Nature and Man in America* (New York, 1891), p. 184. The assumption is not valid for the Southeast, where the clearing of the woods and the incidental making of pastures must have antedated the coming of the bison by many centuries.

[65] Regions mentioned as abandoned: most of the lower Mississippi Valley above the mouth of the Red River, the Gulf coast from Tampa Bay to Mobile Bay, the Georgia coast, parts of interior Georgia, and certain settled areas along the Chattahoochee, Black Warrior, and Etowah rivers. Swanton, "The Indians of the Southeastern United States," *op. cit.*, pp. 11–21.

[66] William G. Haag, "A Prehistory of Mississippi," *Journal of Mississippi History*, Vol. 17, No. 2 (1955), p. 27. The cause of the population decline does not seem to be fully understood, but diseases contracted from the Europeans must surely have been among the potent reasons.

INDIAN PASTORALISTS OF THE GUAJIRA PENINSULA[1]

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EXTENDING northeastward from the Sierra Nevada de Santa Marta to form the northernmost tip of South America, the Guajira Peninsula is a notably dry and unattractive land. Almost all of its 60,000 inhabitants are Indians, both racially and culturally. They speak the native tongue and identify themselves as Guajiras and as members of a particular clan rather than as citizens of Colombia or Venezuela; they practice bride purchase and polygyny, matrilineal inheritance of property, and are governed by tribal law in the settlement of disputes. Despite their extreme poverty, Guajira Indians have managed to induce most of the few immigrants to their barren homeland to learn their language and follow Indian customs. The growing numbers of emigrants to more favored lands outside the peninsula are maintaining their linguistic and cultural identity.

Raising livestock not only constitutes the essential basis of the native economy in the Guajira Peninsula, but is intimately involved in the value system and social structure of the Indian society. The adoption of this economic complex and the organization of a culture around it is entirely a post-Columbian development. This paper will attempt to examine this acculturative phenomenon and the nature of the area in which it occurred, and to suggest how and why this Indian group was able to borrow so heavily of European economic systems and technology and to integrate this new way of life into a culture of such vitality that it is successfully resisting the efforts of two strongly assimilative countries to absorb the Indians in their national societies.

PHYSICAL CHARACTERISTICS OF THE GUAJIRA PENINSULA

Topographically the region contains two distinctive sectors of almost equal area, known locally as the Alta and Baja Guajira. The Baja Guajira forms the base of the peninsula and is almost perfectly flat. Unconsolidated marine sediments lie at less than 100 feet above sea level, and there is proportionately little local relief. Both the surface and the rock composition of the Alta Guajira are more complex. Ranges of crystalline rock which must have once formed a small archipelago reach elevations of from 2000 to 3000 feet. They rise without any general pattern of orientation from a terraced platform, part of which is old crystalline rock, part early Tertiary and pre-Tertiary sediments, and part Quaternary deposits. The platform terraces are several and step down from about 300 feet in the interior to perhaps 40 feet near the coast. The form and distribution of these terraces indicate that they were formed by marine planation during the high sea levels of the Pleistocene interglacials; the shallow waters offshore and the cliffed coast suggest that the same process is continuing.

Though it has little or no surface expression to the eastward, the fault which forms the northern face of the Sierra Nevada de Santa Marta continues at least to the Gulf of Venezuela, passing by the northern tip of the Montes de Oca, a relatively low range of folded sedimentary rocks of Mesozoic age and Andean deformation. East of the Río Ranchería, which rises in the eastern Sierra Nevada, the many streams that come out of the humid Montes de Oca sink abruptly into the ground in the vicinity of the fault line and evidently move underground to the east, approaching the surface in the lowlands along the Gulf of Venezuela and the north end of Lake Maracaibo. As a result of this subterranean discontinuity there is no flow of ground water from the south into the porous sediments of the Colombian Baja Guajira. Along the dry coast of the Gulf of Venezuela north of Sinamaica extensive coconut plantations are supported by ground water, and shallow wells yield a substantial quantity of fresh water. The comparably dry Caribbean coast east of Rio Hacha does not have these advantages.

For most of the year the climate of the Guajira is dominated by the northeast trade

[1] Field work in the Guajira Peninsula during the summers of 1954 and 1955 was supported by the Associates in Tropical Biogeography of the University of California and by the Geography Branch, Office of Naval Research under Contract 222(11)NR388067. This assistance is gratefully acknowledged.

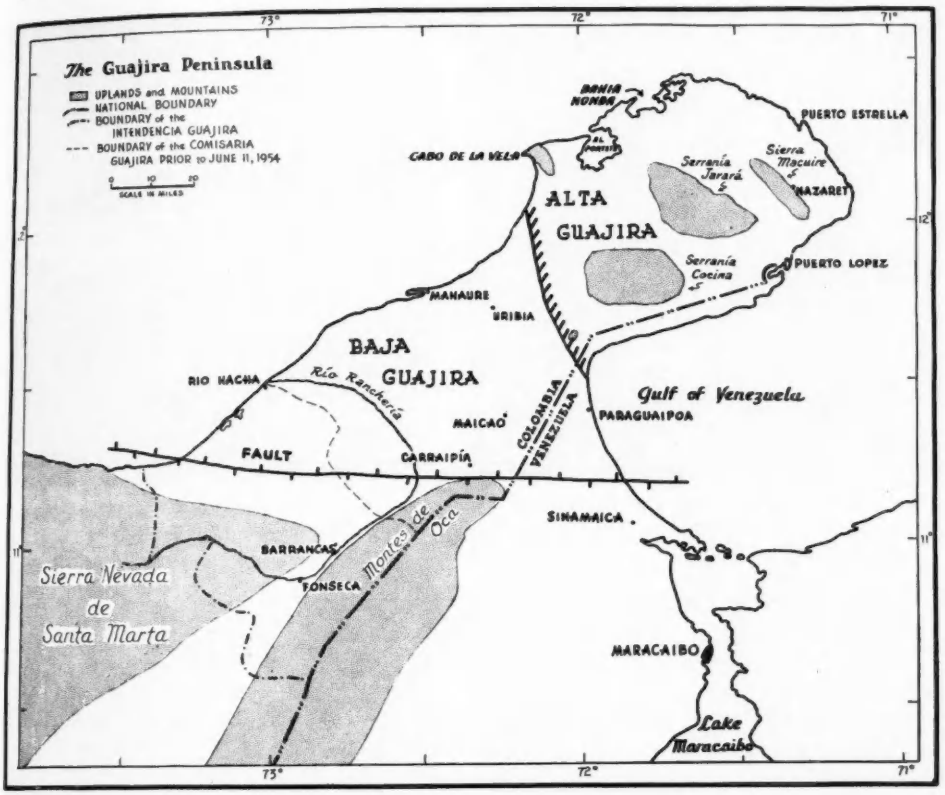

FIG. 1. The Guajira Peninsula.

winds which carry warm and moist but extremely stable air across the peninsula. Where forced to rise over a major topographic barrier like the north face of the Sierra Nevada, they yield heavy precipitation. The low ranges of the Alta Guajira collect only a light mist from a shallow cloud deck that forms on their crests. As the trade winds progress inland and southward, however, they lose their stability. The Montes de Oca is a range no higher than the Sierra Macuire in the Alta Guajira, but the condensation that develops as the trades rise over it results in free convection, towering cumulus clouds, and sufficient precipitation to support a tropical rainforest. In the Guajira proper significant precipitation occurs only in association with the easterly waves that move across the Southern Caribbean in May and June and more vigorously in September, October, and November. As these waves pass the air loses its stability and cumulus clouds and violent convectional precipitation may occur.[2]

A remarkably steep precipitation gradient crosses the Guajira from south to north. Unfortunately station records are few and short and stations are not ideally located, but the character of the natural vegetation is consistent with what record there is and provides supplementary information. At the foot of the Montes de Oca just south of Carraipía a great forest suggests an average annual rainfall of about 60 inches. Fifteen miles to the north near Marañamana, the dry savanna indicates about 35 inches, and short station records at Uribia and Manaure, some 30 miles farther north, show average annual rainfalls of 16 and 15 inches, respectively. Finally, Bahía Honda at the extreme north of the peninsula gets less

[2] Cf. Herbert Riehl, *Tropical Meteorology* (New York: McGraw–Hill, 1954), pp. 210–19.

FIG. 2. Rainforest at the northern foot of the Montes de Oca just south of Carraipía. Except during major floods the water of this river will disappear underground in the fault zone within a few miles.

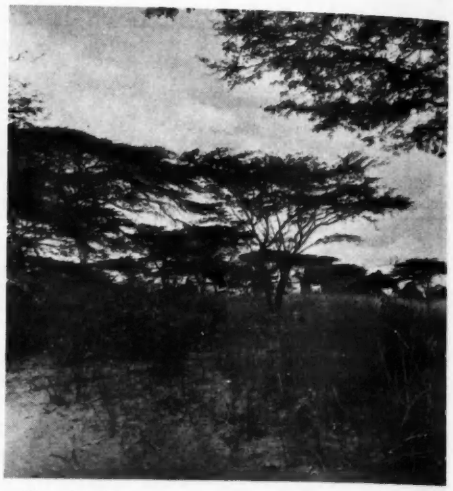

FIG. 3. Dry savanna in the vicinity of Marañamana, about ten miles north of Carraipía.

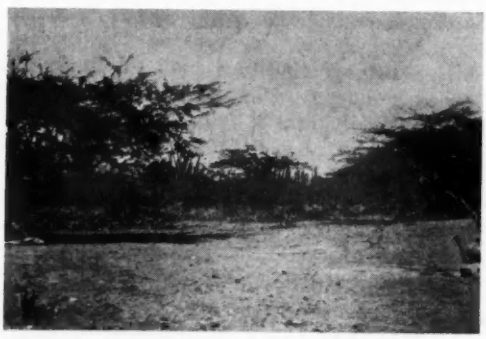

FIG. 4. Thorn scrub in the vicinity of Uribia.

FIG. 5. The full desert at Cabo de la Vela at the northern edge of the Alta Guajira.

Figures 2–5 show the vegetational contrasts in a 70-mile transect across the Guajira from south to north. The steep climatic gradient which the changes in natural vegetation indicate occurs in terrain of little or no relief.

than 8 inches per year, fully desert conditions in an area with an average annual temperature in the neighborhood of 80°F. In and adjacent to the low ranges in the Alta Guajira, slightly higher precipitation values obtain, perhaps ranging from 15 to 30 inches per year.

Furthermore, the available instrumental record clearly shows that as the average annual precipitation decreases, its variability increases. The frequency and intensity of the easterly waves is highly variable, and on the dry side of the 20-inch isohyet there have been many years with less than four storms and a total of four inches of rainfall. Conversely, at Uribia in October of 1954, following a 12-month dry spell, some 15 inches of rain fell during a single 36-hour period.

The vegetative responses to this climatic pattern vary with edaphic conditions, but are generally characterized by thorny brush, especially the legumes *Prosopis* (a mesquite locally known as *trupío*), *Libidibia* (divi-divi), and *Cercidium*, and various Euphorbiaceae,

Chenopodiaceae, and Cactaceae. The plants are smaller and more widely spaced in the drier districts. Following good rains a full cover of herbaceous annuals springs up in all unshaded localities. Native grasses are rare if not completely absent.

Permanent water sources in the rougher portions of the Alta Guajira occur, as might be expected, where ground water percolates slowly through the rubble in the arroyo bottoms and is brought to the surface where it must cross a hard rock dike. The Franciscan mission station at Nazaret is located at such a spot. In flat areas and in the Baja Guajira, however, once the surface pools dry up following a rain, pits, locally known as *jagüeyes* or *casimbas*, must be dug in arroyo bottoms or other low spots to intercept water that has soaked down from the surface. The ground water table is seldom more than 60 feet from the surface, but the yield is small, and if a well is deepened the water from greater depths almost always proves to be lethally saline. Even the top lens is notably full of dissolved salts. The salt content of the ground water appears to be derived from the local marine sediments; it has been maintained since Pleistocene times by an almost complete absence of horizontal flow to flush out the salt.

HISTORY OF HUMAN OCCUPATION OF THE GUAJIRA

As the preceding discussion should indicate, in all but its western and southern edges, the Guajira is a singularly unattractive portion of the earth's surface. It is, however, unusually accessible from the sea. Pearl fishing was carried on along the north coast by the Spaniards as early as the first half of the sixteenth century, and projects to create a naval base at the great natural harbor of Bahía Honda appear in the documents throughout the colonial period; Bolívar would have placed his international capital there. The complete absence of potable water always made such schemes hopeless. Rio Hacha, at the western corner of the region and favored by an adjacent perennial stream, was founded in 1545. It served as a base for pearling operations and for exploiting the dyewoods (brasilwood, *Haematoxylon*, and divi-divi, *Libidibia*) which formed an important fraction of the thorn forest to the south and west. Despite its unprotected roadstead and the extremely shallow water offshore, this town has been continuously occupied, though early depletion of the natural products it traded precluded any great prosperity or development. At Sinamaica, guarding the entrance to Lake Maracaibo, a similarly early Spanish settlement was established. In the lowlands and foothills south and west of Rio Hacha, there is enough and sufficiently regular precipitation to permit agricultural settlement and permanent grazing activities. The sedentary Indians were quickly conquered and *encomiendas* and later *haciendas* created a typical Latin-American colonial economy.

But in the Guajira proper to the east, farming and even grazing were too precarious to attract any permanent Spanish settlers. Contact with the Spanish settlements was sufficiently close to permit the Indians of the Guajira Peninsula to acquire livestock by trading or raiding, and they have adopted a pastoral economy, adapted their culture to fit it, and survive in their inhospitable land as a vital and distinctive cultural and linguistic entity. A cultural geographer from the western United States is immediately struck by the similarity of both these environmental restrictions and culture–historical developments to those that were occurring in the Navajo country of Arizona and New Mexico during the same span of time.

It is clear that the present pastoral economy can support more people in this dry land than any economy that could have existed prior to the introduction of domesticated animals. Without such, extensive areas in the Guajira, especially in the interior, are nearly uninhabitable. Archeology and the accounts of the first Europeans to visit the peninsula are our sources of information on the pre-Columbian human occupation of the region. While no thorough archeological examination has been made, my own hurried survey of the region shows a marked contrast between the abundant sites south and east of the Río Ranchería and in Venezuela south of Paraguaipoa, and the scarcity and poverty of sites farther out in the peninsula.

In and east of the Río Ranchería Valley, cultivation is feasible and sites are extensive and full of varied pottery. Permanent early settlements by a farming population are clearly indicated, though there is some indi-

cation of a decline in density of population just before the conquest. At Barrancas the fineness of the pottery through a long sequence of cultures, well defined stratigraphically, suggests a high culture like that of the Tairona of the western Sierra Nevada.[3] The relative abundance of water near the coast south of Paraguaipoa seems to have made possible permanent settlements, though perhaps of fishermen rather than farmers. Farther out in the peninsula the only evidence of prehistoric farming comes from the mouth of a canyon at the eastern foot of the Sierra Macuire where a small stream flows permanently for a few hundred yards. Some crude pottery was unearthed there, several feet below the surface, during the digging of a deep *jagüey* during the last few years.

Along the coast there are small shell middens. I know of no permanent springs of potable water which exist on the beaches east of Rio Hacha and north of Paraguaipoa, and the small shallow middens, many of them quite modern, suggest that the people dependent on marine resources were few and highly mobile by necessity.

Juan de Castellanos[4] noted that about 1550 the coast near Cabo de la Vela was occupied by extremely savage and primitive hunters and fishermen whom he called Cosinas. Digging pits or *jagüeyes* for drinking water was part of their culture. These Cosinas recur in the literature of the eighteenth and nineteenth centuries when they were raiders who threatened the overland route of communication between Rio Hacha and Sinamaica. They are said to have raided but not cared for livestock and lived in the Serranía Cosina, basically by hunting and gathering.[5] Local tradition has it that they were finally exterminated by the pastoralist Guajira Indians during the nineteenth century, though some outcast and poor Indians in the same area were called Cosinas and were feared as brigands until very recent times.[6]

The pre-Columbian picture then can be seen in these terms. A numerous population of sedentary farmers, probably speaking Arawak as do the modern Guajira, occupied the western and southern margins of the Guajira Peninsula. A much simpler hunting, gathering, and fishing population occupied the bulk of the peninsula, with perhaps a few farming communities living at favored sites.

Though they worked the whole north coast of the Guajira for pearls, enduring occupation of the mainland by the Spaniards occurred only in the lands which had an agricultural population.[7] It is likely that a substantial proportion of these Indians fled eastward into lands that the Spaniards could not exploit profitably. The pronounced similarities in narrative detail, though not in philosophical themes, of the mythic traditions of the Guajira and the now quite isolated highland Indians of the Sierra Nevada de Santa Marta suggest former contact much closer than would now be possible.[8] In addition, in the mid-eighteenth century the Guajira were notorious for their heavy use of coca leaves, chewed with lime.[9] This culture trait, which they have now lost, is clearly derived from the Sierra Nevada where the plant can grow and where the Indians still use it.

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[3] Gerardo Reichel-Dolmatoff, "A Preliminary Study of Space and Time Perspective in Northern Colombia," *American Antiquity*, Vol. 11, No. 4 (Apr., 1954), pp. 252–66, and "Investigaciones Arqueológicas en el Depto. del Magdalena, Colombia—1946–1950, Pt. I—Arqueología del Río Ranchería," *Boletín de Arqueología*, Vol. III (1951), pp. 19–208.

[4] *Elegías de Varones Ilustres de Indias* (Madrid, 1944), pp. 192–295, 250 (original edition, 1589).

[5] José Nicholas de la Rosa, *Floresta de la Santa Iglesia Catedral de la Ciudad y Provincia de Santa Marta* (Barranquilla, 1945), pp. 286–87 (original edition, 1739); Antonio Julian, *La Perla de la America* (Bogotá, 1951), pp. 222, 226–27 (original edition, 1787).

[6] Gustaf Bolinder, *Indians on Horseback* (London, 1957), pp. 150–58.

[7] Castellanos, *op. cit.*, pp. 250–52, indicates that by the late sixteenth century Spanish settlements with extensive cattle ranches had been established at Rio Hacha, Barrancas, and Cabo de la Vela. The latter place, in the dry heart of the Guajira, was abandoned before 1600 as the pearl oyster beds were depleted. It is conceivable that the stock was taken over by the local Indians at this time, but a careful reading of Castellanos offers no support for the interpretation that the Indians were already pastoralists by 1550. Cf. Gregorio Hernandez de Alba, *Etnología Guajira* (Bogotá, 1936), pp. 14–15; John M. Armstrong and Alfred Métreaux, "The Goajiro," *Handbook of South American Indians*, Bureau of American Ethnology, Bulletin 143 (1948), Vol. 4, p. 369.

[8] Gerardo Reichel-Dolmatoff, *Los Kogi—Una Tribú de la Sierra Nevada de Santa Marta—Colombia*, Vol. II (Bogotá, 1951); Roberto Pineda Giraldo, "Aspectos de la Magía en la Guajira," *Revista del Instituto Etnológico Nacional*, Vol. 3, No. V (Bogotá, 1950).

[9] Julian, *op. cit.*, pp. 49–65; Nicolas de la Rosa, *op. cit.*, pp. 282–83.

The modern Guajira population then is derived from a mixture of two groups. The more numerous element were former horticulturists who withdrew into the steppes and deserts to evade Spanish domination. There they mixed with some of the autochthonous hunters and gatherers. But in the course of leaving the regions of Spanish settlement they brought along some livestock. Cattle, horses, mules, and asses are mentioned in the early accounts, although, because they are far better adapted to the terrain and pasture, goats and sheep are at present the most important animals. Riding, tending, and watering of herds and flocks, and even branding with a clan symbol, are fully developed arts and were reported as early as the eighteenth century. They can only have come from intimate contact with the Spanish settlements.

In the eighteenth and nineteenth centuries a continuing series of border raids, Indian stock stealing and Spanish punitive expeditions, flared along the Río Ranchería which continued to be the Indian Frontier. An enormously expensive project to Christianize and reduce the Indians beyond this frontier to permanent pacified settlements was undertaken from 1770 to 1773; small stock in great numbers were given to Indian chiefs and family heads who would agree to settle down at a few designated garrisons. The project's expense was inherently prohibitive, but failure and withdrawal of the garrisons was impelled by a drought which forced the Indians to spread out with their stock to all the scattered waterholes, or have them starve.[10] The wars of independence followed shortly, and revolutions and provincial efforts to maintain local autonomy have featured Colombia's nineteenth-century history. This political unrest prevented the national government from concentrating its attention on bringing the Indians of the Guajira under its effective rule. Furthermore, since Guajira chiefs could sell horses to one side or the other during a revolution, both political parties found it essential not to incur their enmity.

In sum, then, the Indians of the Guajira peninsula were exposed to continuous but, except in the 1550's and in the 1770's, light contacts with nearby Spanish settlements throughout the period from 1500 until the 1920's. Another type of contact with outsiders has also been important from the early seventeenth century to the present time, namely, that of smuggling and contraband trading, especially with the Dutch and English. The long exposed coastline, and the absence of effective official control made the peninsula extremely attractive for such operations. In the mid-eighteenth century there were many complaints that the Indians were acquiring modern weapons and Negro slaves in exchange for pearls, dyewoods, hides, and provisions.[11] Smuggling is still a major activity, and small boats from Aruba and Curaçao with a variety of trade goods come in to unwatched beaches regularly. The long desolate boundary between Colombia and Venezuela enhances the opportunities for profits, some of which are taken by the Guajira women, whose voluminous dresses or *mantas* are ideal for smuggling, the women being protected from search by the Hispanic tradition of sexual propriety.

ECOLOGY AND CULTURE OF THE MODERN GUAJIRA INDIANS

During this long period of contact it has been possible for the Indians to adapt the borrowed technology of a pastoral economy and notions of trade and commerce into an integrated and dynamic new culture and social structure that competes with amazing vitality and success with the generally strongly assimilative national cultures that surround it. The following paired items indicate some of the apparently incompatible social patterns that are effectively integrated in this culture: Inheritance of property and membership in a clan are matrilineal, but marriage is by purchase, the preferred currency being livestock, and a rich man may buy as many wives as he chooses. There is a strong clan organization with fiscal and even blood responsibility for the welfare and the behavior of its members, but property is all privately owned, and within a clan there are individuals who own great herds and others who are completely propertyless and are completely dependent on the largesse of a wealthy man.

These apparently anomalous customs have survival values for the culture. An immigrant

[10] *Diario de la expedicion ael Rio de la Hacha . . .*, 1772–1773, manuscript in Archivo Nacional, Bogotá.

[11] Julian, *op. cit.*, pp. 225–27.

FIG. 6. The women of a Guajira family in their characteristic *mantas*. The face painting exhibited by the woman on the right is common and is done with charcoal or the spores of a native fungus mixed with sheep fat. Women say that they paint their faces to keep cool, but a pale skin is also regarded as a mark of beauty.

to the Guajira, often a Levantine trader in smuggled goods, will buy a native wife, commonly one from the most wealthy and powerful family he can afford, and a desirable marriage may cost several hundred cattle. Children of this union have automatic status in their mother's clan and will inherit property from their mother's brothers. Such children have commonly chosen to identify themselves with the Indian rather than with the Colombian culture. Only the offspring of cheap marriages, individuals who are not to be emulated, are likely to seek to identify with their father's culture. Similarly the institution of private property in herds assures that each owner will use all his energy and ingenuity to protect his stock in times of stress caused by the recurring droughts, while the clan organization protects the individual who fails to do so from starvation. The tradition of private property also tends to make the Indian capable of taking care of himself in commercial dealings with outsiders.

FIG. 7. A mixed flock of goats and sheep coming in to a watering place in the thorn scrub some 20 miles east of Rio Hacha.

The Guajira have a strong tradition of male sexual exclusiveness; the absence of virginity will force a reduction in bride price, and illicit sexual relations constitute a tort that must be paid for with blood or money. This value system, rare indeed among American Indians, finds full parallel in Hispanic-American society, as does the stratified socio-economic structure of the society. These characteristics, coupled with pride and confidence in their own language and culture, may explain why the Guajiras enjoy such high social status in Colombia and Venezuela, countries in which Indian groups generally are looked down upon, and where Indian ancestry is denied if physically possible by anyone conscious of his social position. By contrast, in the Colombian towns near the Guajira, leading citizens are happy to claim naked Indians as their close relatives and cultivate their ability to speak the Guayú tongue. It may well be that this language is even now acquiring outside bilinguals as fast as the Indians are learning Spanish as a second language.

Antonio Julian[12] in the latter part of the eighteenth century estimated the Guajira population at between 16,000 and 20,000. He thought it was decreasing, but such a number could survive in this barren territory only with the aid of a pastoral economy. At present about 60,000 Guajiras live in the approximately 6,000 square miles of the Guajira proper of both Venezuela and Colombia, a population density which in a primarily pastoral economy can be supported only at a low level of living, even in years of adequate rainfall when pasture is good and water sources

[12] *Ibid.*, p. 222.

FIG. 8. A water source in an arroyo bottom near the north coast of the peninsula. In this fenced-in low spot a number of pits from four to eight feet deep have been dug. A few inches of water covered with a thick green scum is in the bottom of some of the deeper pits. Hollowed logs set in the brush fence are filled to water livestock. Note how the mesquite trees in the vicinity are trimmed as high as a goat can nibble.

FIG. 9. An Indian obtaining water from a 30-foot-deep *jagüey*. With his 5-gallon oil can he makes repeated trips, pouring the water into a hollowed log to water about 100 cattle.

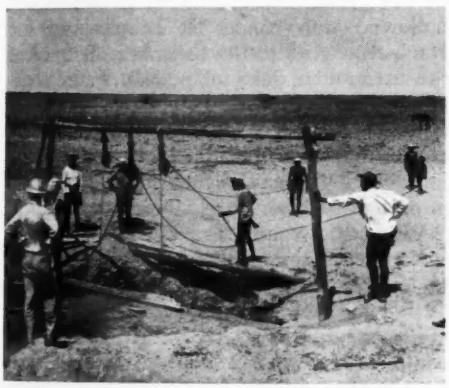

FIG. 10. The well of a wealthy native stock owner. This well is about 60 feet deep and at the bottom two men are filling 5-gallon cans from small seeps; the cans are to be drawn up by the lines and pulleys. The sides of the well are sandy clay and there is no shoring. Men of the retainer or serf class work all day at this task when there is no water available at the surface.

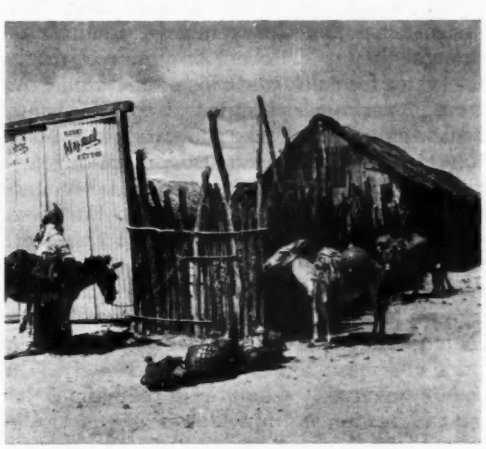

FIG. 11. At the government-operated salt works at Manaure there is a deep well that yields barely potable water. Women come from waterless fishing villages as much as 15 miles away to obtain drinking water. The water jugs are of the characteristic style and local manufacture.

are available throughout the territory. During the recurring droughts, when many water holes dry up and the poor pasture is exhausted around many of the few persisting water sources, the Indians must sell much of their stock or let it starve, and emigration is necessary. Perhaps 20,000 Guajiras have moved to Maracaibo where they work as unskilled laborers and form almost the entire population of Barrio Ziruma on the northern edge of the city. Another 10,000 have moved to the Colombian settlements to the southwest along the upper César and Ranchería rivers; they pasture a few goats and cultivate small

fields hacked out of the *monte* in this somewhat more humid region, taking such temporary unskilled jobs on roads and in the towns as may be available. This emigrant flow can hardly do other than increase, and while the acculturative pressures on the Indian are much greater once he leaves the Guajira Peninsula, there are enough emigrants to form whole Indian communities in most of the places to which they move. In the Barrio Zuruma, for example, practically all the women continue to wear the loose flowing *manta*, though the men have been forced to wear trousers over the native *guayuco* or breechclout.

Though only a few families own substantial herds, most of the Guajiras in the peninsula regard pastoral activities as their principal employment. When pasture is good and drinking water widely accessible, men with few or no animals are underemployed. They may tend the herds of a rich man or dig and maintain *jagüeyes* for him, but primarily they are just maintained as retainers. In times of drought they will be kept busy indeed, drawing water for stock in earthen jugs or oil cans from pits as much as 60 feet deep. Herds are broken into small flocks and carefully tended to seek out all the pasture within walking distance of a water hole. Branches of taller mesquite trees may be cut for fodder. For these services maintenance but no pay is expected, and some students of the Guajiras have spoken of this propertyless class of retainers as serfs or slaves. Without the cooperation of their patron they could never pay the bride price and marry.

At a few irrigated *huertas* at the base of the Sierra Macuire, and in widely scattered localities around the southern and western borders of the peninsula, some Indians will clear a patch of ground and plant crops. Sweet *yuca*, sesame, beans, and maize are the most important field crops. Often, because the seasonal rains fail to come, a clearing is not even planted. Yields vary directly and widely with the rainfall. The Franciscan missionaries have vigorously encouraged increasing attention to farming, but the highly uncertain yields and the small patch of land that can be cultivated by hand tools convince the Indian that agriculture as a way of life yields returns that are at best meager and are also precarious. In the most favored district, south and west of Carraipía, mechanized clearing and the cultivation of cotton on a commercial basis is being undertaken, but this enterprise is largely restricted to non-Indian immigrants.

FIG. 12. Canoes beached at the fishing village of Carrizal, 20 miles northeast of Manaure.

Fishing villages are to be found along the coast, but they are both smaller and more widely scattered than might be expected in this hungry land. Great logs from the forests on the north face of the Sierra Nevada are hollowed into canoes at Dibulla and Rio Hacha and sold to the fishermen. Because of the extreme scarcity of potable water at almost all coastal sites, life in the fishing villages is unpleasant. While the fisherman's family may enjoy relative food security, they must get by on a daily burro load of water, often hauled from a well 15 miles away.

While there are clear disadvantages to a fishing or farming life, people who follow them might be considered far better off than all but the richest herdsmen. The activity of herdsman, however, has social prestige. Desirable wives can be obtained only for livestock and by stock owners. Whenever a fisherman or farmer has had modest success, he is likely to convert his capital to livestock and become a herdsman, even though he is entering a crowded and more precarious business.

Weaving imported cotton thread into *chinchorros* (net-like hammocks) and belts and bags is a genteel occupation for women. The quality of weaving is excellent and the products never saturate the market, but the return per hour of labor for this handwork is low and at best a supplementary source of income. Poorer women in some isolated localities make large round pottery jars for carrying water,

FIG. 13. One of a number of well-stocked stores in the village of Maicao near the Venezuelan border. Prices are far lower than in Venezuela or in most of Colombia.

though they must compete with the ubiquitous five-gallon oil can.

The number of trading establishments scattered through the peninsula is enormous, especially in view of the low productivity of the region and the poverty of the people. A large fraction of these establishments make a raw bootleg rum from imported *panela* or brown sugar cake for part of their income, but it is likely that some aspect of the smuggling business really supports them. Procurement of accurate information on the network of sources of supply and markets for such activity is obviously difficult, but a large fraction of the stock at the most isolated store is likely to consist of American cigarettes, French cognac, and fancy lingerie, all available at low prices and all items that are subject to high tariffs in both Colombia and Venezuela. Many of the traders entered the peninsula well before it was brought under effective military control in the 1930's. The most successful traders and smugglers always found it almost essential to purchase an expensive bride from a powerful family, thereby gaining allies and protectors. Now a second generation is taking over the family businesses; it consists of men who identify themselves with their mothers' clans and the Guajira culture but who also possess a full generation of commercial experience acquired through association with their Levantine fathers. Such Indians are not likely to be vulnerable in the modern business world.

PROSPECTS FOR THE GUAJIRAS

When a severe drought hits extensive areas in the peninsula and the poorer Indians have lost their crops and small herds, starvation threatens; Indians try to subsist on the stems of the columnar cacti; small children are sold or given to anyone who will offer to feed them, and emigrants drift with their surviving flocks, if any, toward the towns to the south and west. Both Colombia and Venezuela have during the last two decades instituted major projects to alleviate this acute distress among their Indian subjects. The Colombian efforts have been greater since the bulk of the area is theirs, and have taken two forms. One is the salt evaporating works at Manaure, operated by the Banco de la Republica as part of the government salt monopoly. Labor-saving devices are not used since a major goal is to provide employment and income to a maximum number of Indians. Also, a project to drill wells and to construct great catchment pits, or basins if the terrain makes this feasible, for the seasonal rains has been operated for some years. The basic notion is that starvation of stock during droughts occurs because pasture is completely exhausted within walking distance of the few enduring water sources. If water sources were better distributed, there would be sufficient pasture for the stock to survive until the drought broke.

The inherent fallacy of this program is that the whole region is already nearly saturated with animals and most of the people are extremely poor. A ten-percent increase in herd size would improve the general level of life very little, and not for long. If the individual Guajira wishes to improve his living standard, he can emigrate and enter the bottom of the national society of either Colombia or Venezuela, and under extreme pressure many do. But to the present time enough have preferred to endure hard times in their hard land, in hope of ultimately gaining great herds and a position of status in their own society, to keep their culture vital.

There is no intention of suggesting that the Guajira culture provides an idyllically pleasant social environment for its participants.

FIG. 14. An arroyo course in the Alta Guajira has been dammed by the government and some water remains after rains which occurred four months earlier. Note how the natural vegetation has been nearly eliminated from the vicinity of this water source.

FIG. 15. In the nearly flat Baja Guajira the Colombian government is excavating T-shaped pits like this across the broad, little-incised water courses. These will fill with water following a heavy rain and hold it for several months.

Almost the reverse is true, and everyone is under severe stresses. The man who inherits extensive property must strive to maintain or increase it under conditions of severe environmental restrictions. The man who inherits nothing lives under conditions of servitude and social debasement; he may not be able to marry, and often he experiences real hunger. Prolonged and violent drunkenness and both drunken and sober fights are extremely common throughout the peninsula,[13] and among the Guajira residents of Maracaibo the incidence of insanity, so extreme as to require institutionalization even by the tolerant local standards, is a serious concern to the Venezuelan authorities. The Guajira Indian, within his culture and out of it, is not calmly adjusted to his lot; he is an aggressive, fairly unhappy individual on the make. This personality type which the Guajira culture tends to produce may be a major factor making it possible for these Indians to survive individually and culturally in competition with the similarly stress-producing larger societies that surround them in the modern world.

[13] Cf. Bolinder, *op. cit.*, pp. 36–39; Raymond E. Crist, "The Land and People of the Guajira Peninsula," *Smithsonian Institution Report for 1957*, pp. 352–53.

THE HIERARCHY OF CENTRAL FUNCTIONS WITHIN THE CITY

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WHEN this survey was begun in 1952, it was, to my knowledge, the first attempt to use the central place concept for analyzing the pattern of central functions within the city. It was felt that such a study would strengthen the functional approach in urban geography. The methods which were used in the survey did also prove useful for solving practical problems of business location and city planning. Those problems led, as a matter of fact, to the initiation of the survey.

Although this article is based on studies in one specific city—Zurich, Switzerland—it is expected that its approach, its methods and results will be of general interest to the urban geographer. The study aims at a qualitative presentation of the findings rather than at an exact quantitative record of data. The findings of the survey, as far as they were of interest to the general public, were printed in April, 1957, in the form of a series of articles in the leading newspaper of Zurich, the *Neue Zürcher Zeitung*.[1]

Reviewing the literature concerning the central place concept, it is interesting to note how strongly the German-speaking geographers have concentrated their efforts on the external classification of settlements as central places, and also on the establishment of the relationship of these settlements to their service areas. They followed the lead given by Hassinger, Bobek, Christaller, and others. English-speaking, and other geographers as well, have made contributions to the external as well as to the internal functional analyses.[2] However, not until very recently has the central place concept been consciously applied to studies of central functions within the city. Berry states very clearly the scope of central place theory:

> Parallels between findings concerning the nucleated business types and studies of central places are in general so strong that it can only be concluded that central place theory is applicable to the analysis of the size, spacing, and functions of nucleated shopping centers located within cities as well as to functional characteristics, etc., of alternative urban settlements. Arguments and premises inherent to central place theory are sufficient to provide a logical and satisfactory explanatory scheme of the entire set of nucleated business centers. But cen-

[1] For help in writing this article in English, the author is grateful to C. Trautvetter, E. W. Griffin, and P. G. Mika.

[2] H. Hassinger, "Basel," *Festschrift zum 22. deutschen Geographentag in Karlsruhe* (Breslau, 1927); H. Bobek, "Innsbruck, eine Gebirgsstadt," *Forschungen zur deutschen Landeskunde* (Stuttgart, 1928); W. Christaller, *Die zentralen Orte in Süddeutschland* (Jena, 1933); R. E. Dickinson, "The Markets and Market Areas of East Anglia," *Economic Geography*, Vol. X (1934), pp. 172–82; M. J. Proudfoot, *The Major Outlying Business Centers of Chicago* (University of Chicago, 1938); W. William-Olsson, "Stockholm, Its Structure and Development," *Geographical Review*, Vol. XXX (1940), pp. 420–38; C. D. Harris, *Salt Lake City, a Regional Capital* (University of Chicago, 1940); E. L. Ullman, "A Theory of Location for Cities," *American Journal of Sociology*, Vol. XLVI (1941), pp. 853–64; H. M. Mayer, "Patterns and Trends of Chicago's Outlying Business Centers," *Journal of Land and Public Utility Economics*, Vol. XVIII (1942), pp. 4–16; R. E. Dickinson, *City, Region and Regionalism* (London, 1947); H. Carol, "Industrie und Siedlungsplanung," *Plan, Schweizerische Zeitschrift für Landes-, Regional-, und Ortsplanung*, Vol. VIII (1951), pp. 191–206; H. Carol, "Das agrargeographische Betrachtungssystem, Ein Beitrag zur landschaftskundlichen Methodik, dargelegt am Beispiel der Karru in Südafrika," *Geographica Helvetica*, Vol. VII (1952), pp. 17–67; P. Schöller, "Aufgaben und Probleme der Stadtgeographie," *Erdkunde*, Vol. VII (1953), pp. 161–84; J. E. Brush, "The Hierarchy of Central Places in Southwestern Wisconsin," *Geographical Review*, Vol. XLIII (1953), pp. 380–402; R. E. Murphy and J. E. Vance, Jr., "Delimiting the CBD," *Economic Geography*, Vol. XXX, No. 3 (1954), pp. 189–222; R. E. Murphy and J. E. Vance, Jr., "A Comparative Study of Nine Central Business Districts," *ibid.*, Vol. XXX, No. 4 (1954), pp. 301–36; R. E. Murphy, J. E. Vance, Jr., and B. J. Epstein, "Internal Structure of the CBD," *ibid.*, Vol. XXXI, No. 1 (1955), pp. 21–46; W. Applebaum and B. L. Schapker, "A Quarter Century of Change in Cincinnati Business Centers," *The Cincinnati Enquirer* (Cincinnati, 1956); J. Spelt, *The Urban Development in South-Central Ontario* (Assen, 1955); H. Carol, "Sozialräumliche Gliederung und planerische Gestaltung des Grosstadtbereiches, dargestellt am Beispiel Zürich," *Raumforschung und Raumordnung*, Vol. XIV (1956), pp. 80–92; A. K. Philbrick, "Principles of Areal Functional Organization in Regional Human Geography," *Economic Geography*, Vol. XXXIII (1957), pp. 299–336; B. J. L. Berry and W. L. Garrison, "The Functional Bases of the Central Place Hierarchy," *ibid.*, Vol. XXXIV (1958), pp. 145–54; S. B. Cohen and W. Applebaum, "Evaluating Store Sites and Determining Store Rents, *ibid.*, Vol. XXXVI (1960), pp. 1–35.

tral place theory, at least in its present form, is not adequate to explain stretches of highway-oriented or urban arterial businesses. Neither is it adequate to account for specialized functional areas, such as automobile row. Some broader body of theory seems necessary to account for the spatial structure of all types of retail and service business.[3]

In comparing at a glance American with European cities, it is interesting to note what Berry and others correctly state: that the pattern of distribution of central services in American cities is still nucleated. Also, the new car-shopping centers are modern adaptations of the central place principle. On the other hand, due to the great mobility of Americans, a number of other kinds of business locations have evolved which do have a counterpart in European cities, but which appear there in less pronounced forms.

The Zurich study does not attempt to include all kinds of business areas, but focuses exclusively on the distribution of truly central functions and their grouping into nucleated business districts. Those centers form the basic functional pattern of the city. For a complete functional analysis of the modern city, the arterial business locations, the traffic patterns, and all truly non-central functions, such as manufacturing, recreation, and housing, would also have to be taken into account.

TERMS AND DEFINITIONS

The following terms have evolved during many years of practical work with the central place concept at the Department of Geography, Zurich University. These terms are partly modified revisions of the original ones which were created by Christaller in 1933. To facilitate comparison of publications in English with those in German, the terms are also mentioned in German.

Central services or *central functions* (*Zentrale Dienste, zentrale Funktionen*), such as the supply of consumer goods or medical care, are the outgrowth of *personal contact* between the central service and its customers, thus leading to a close relationship between the residences of the consumers and the location of the service. Assuming a homogeneous group of people with similar needs and means, and assuming an even distribution of such a population, the logical outcome is a regular, predictable distribution of the various central services. This is the essence of central place theory. Central services of the same kind have service areas of the same regular extent, or, more generally, they serve a specific number of people. The size of the service area is dependent on the density of population, or, more precisely, on the density of purchasing power, as Berry puts it.[4] In a densely populated city a general physician may serve a few square miles, while in the Karoo of South Africa, with its very low density, one physician covers a service area of about 2700 square miles! The more commonly used the central services are, the closer is their spacing; the more rarely used they are, the greater is the number of people necessary to support them, and the wider is their spacing. The difference in demand for central services between the more general and the more specialized needs creates a *hierarchy of central services* (*Hierarchie der zentralen Dienste*). There are no such general rules of distribution, there is no such hierarchical order, in *non-central* or *dispersed functions* (*nicht-zentrale, disperse Funktionen*).

The *central place* (*der zentrale Ort*) can be the location of a single central function, or, as the term is generally interpreted, the location of a group of central functions. The *service area* is that area which is served by either a single central function (*Einzugsgebiet*), or by a group of central functions (*Ergänzungsgebiet*). A central place serves the population of its own settlement, the *internal service area* (*internes Ergänzungsgebiet*), and the area adjoining that settlement, the *external service area* or *umland* (*externes Ergänzungsgebiet, Umland*). A central place may have only an internal service area, e.g., the service area of a mining town within an uninhabited region; or, within a city, a local business center which serves exclusively a part of the built-up area. It is a serious mistake to confuse the central place, that is, the location of the central functions, with the concrete settlement in which it occurs. Christaller expresses this fact clearly, but for practical reasons, such as the availability of statistical data, he and many of his followers identified the one with the other in

[3] B. J. L. Berry, "Ribbon Development in the Urban Business Pattern," *Annals*, Association of American Geographers, Vol. XLIX (1959), pp. 145–55.

[4] Berry, *op. cit.*, p. 148.

their work.[5] This is permissible in an area where a settlement has no other than central functions, as demonstrated in my publication on the South African Karoo. Such a condition, however, is the exception rather than the rule.

Upon the hierarchy of central functions is based the *hierarchy of central places* and their corresponding service areas. Christaller was the first to develop the idea of such a hierarchy in his central place theory and a number of scholars have demonstrated the concrete existence of such an order. Each level of the hierarchy has its own corresponding service area. The central place is named according to the level of its highest central functions, thus including all lower ones. During the last decade, I have used a scale of seven main orders, each divided into three sub-orders.[6] Within this general framework, the findings of local studies may be correlated, as demonstrated in Table 1. Philbrick's study shows very clearly the application of this general hierarchy to American conditions.

It was the assumption for this study that the same principles and practical methods which were developed for classifying the rank of settlements, and their umlands, could be utilized for differentiating the functional pattern within town and city.

[5] Christaller defined the "centrality" of a place relatively, namely, as excess function over the needs of the central settlement. Here, on the other hand, it is defined absolutely. What Christaller called "centrality" is, in our terms, the amount of central functions necessary to serve the external service area, the umland. His approach is suitable for the classification of the *basic functions* of that settlement as far as they are derived from central services, but it fails to provide an adequate criterion for characterizing the number and level of central services actually available in a particular central settlement. It also fails to provide a basis for a study of the hierarchy of central functions within the city. The city's administration, for example, does not serve any *external* service area and therefore, according to Christaller, does not enter into the study of central functions. Here, on the other hand, the administration appears as a very important central function for its *internal* service area.

[6] In my previous work (since 1946) the farmstead was considered to be the central place of the entire farm. Therefore, it was called a central place of the first (lowest) order. There is no question about the farmstead being the functional center of the entire farm, but the character of this relation is of a different nature than the relation of a shop or a school serving a number of households. These latter establishments are considered a truly central function of lowest or first order. In this article (Table 1) the first or lowest order designates the central functions which previously were considered to be of second order. On the other hand, the seventh order in this new scale designates truly world-wide functions such as the United Nations headquarters in New York or the Red Cross in Geneva. In the hierarchy of central places, New York may be classified as fully central of the 6th order and sub-central of the 7th order. As yet a world capital does not exist which would be a fully-fledged place of the 7th order.

In this hierarchy of central functions, the lowest functions are considered to be of the first order because they were historically the first to come. More important, they serve the primary needs of the dispersed consumer population. First in need for every household comes the grocery store and much later the high-grade jewelry store. Other authors, however, use a scale in the reverse sense. It would be desirable to discuss such terminological questions on an international level in order to obtain comparable results by the various researchers.

[7] H. Carol, "Die Entwicklung der Stadt Zürich zur Metropole der Schweiz," *Geographische Rundschau*, Vol. V (1953), pp. 304–11.

THE CITY OF ZURICH

Zurich provides an example of a comparatively well-organized European city, unharmed by the war, and, until now, hardly changed by the impact of the "private car era." In 1800, Zurich, with 10,000 inhabitants, was smaller than Geneva, Basle, or Berne. Today, Greater Zurich with half a million people, is twice the size of the next largest Swiss city, Basle. This amazing growth in comparison with the other cities, can be explained by the cumulative effect of two basic economic forces: higher central functions and manufacturing.[7] From the 16th to the 18th centuries, industrial activity spread over certain areas of eastern Switzerland (agriculturally poor, hilly country) in the form of home spinning and weaving. This export industry, which provided a livelihood for the majority of the rural population, was economically controlled by the city of Zurich, which thus established itself as the commercial center of eastern Switzerland. The textile factories, which had sprung up during the Industrial Revolution of the 19th century, were located along the rivers in the area of the old home industry. Thus Zurich maintained its central position in the textile region. Sponsored by the textile mills, machine factories were built in the textile area, and particularly in the city of Zurich. Many railway lines connected the prospering city with its rich and

TABLE 1.—THE HIERARCHY OF CENTRAL PLACES

General hierarchy	Special hierarchies for the highest level of central functions— Of entire settlements: Christaller's scale for Germany	Of entire settlements: Scale for U. S. A.	Of entire settlements: Scale for Switzerland	Of centers within the city: Scale for centers of Zurich	Of centers within the city: Scale for centers within American cities
1st, lowest order					
Sub-central					
Semi-central					
Fully-central		Hamlet[2]	Dorf	Local business district	Local center
2nd, low order					
Sub-central					
Semi-central	Hilfszentraler Ort				
Fully-central	Markt-Ort	Village[2]	Markt-Ort	Neighborhood business district	Neighborhood center[4]
3rd, middle order					
Sub-central	Amts-Ort				
Semi-central	Kreis-Ort				
Fully-central	Bezirks-Ort	Town[2]	Stadt	Regional business district	Community center[4]
4th, high order					
Sub-central					
Semi-central	Gau-Ort				
Fully-central	Provinz-Hauptort	City (Minneapolis)[3]	Gross-Stadt		Regional center[4]
5th, higher order					
Sub-central					
Semi-central			Metropole	Central business district	
Fully-central	Landeszentrale	Metropolis (Chicago)[3]	(Zurich)		Metropolitan center
6th, highest order					
Sub-central	Reichs-Teilort				
Semi-central	Reichs-Hauptort				
Fully-central		Super Metropolis (New York)			Super metropolitan center
7th, world-wide order[1]					

[1] Seventh-order functions are those which are of a truly world-wide scope (see text fn. 6).

[2] According to J. E. Brush, "The Hierarchy of Central Places in Southwestern Wisconsin," *Geographical Review*, Vol. XLIII (1953), pp. 380–402.

[3] According to A. K. Philbrick, "Principles of Areal Functional Organization in Regional Human Geography," *Economic Geography*, Vol. XXXIII (1957), pp. 299–336.

[4] This scale makes use of the terms "neighborhood center," "community center" and "regional center" used by marketing and planning experts, as stated by W. L. Garrison, B. J. L. Berry, and others in *Studies of Highway Development and Geographic Change* (Seattle, 1959), pp. 45–9.

large umland, rapidly industrializing eastern Switzerland. Zurich was the place where capital had been accumulated, and where financial and commercial enterprises had the greatest chance for success; therefore, the central functions rose here above a regional level to nation-wide (metropolitan) level. Today, Zurich lives on the two basic functions: higher central functions and manufacturing. Since World War II tourism has become a third basic factor of considerable importance.

What is the size of Zurich? Rather than by just one criterion it should be defined by various criteria. The municipality within a rather artificial boundary had 410,000 inhabitants in 1955. The continuously built-up area counted 495,000 persons while the metropolitan area included 476,000 inhabitants. Table 2, based on the 1950 census, provides some more details and includes service areas of central functions of various orders.

The growing city incorporated previously independent municipalities of the village type, thus bringing about its present expanded area. Each of the villages which later became a suburb of Zurich had its old established commercial and social center which, in most cases, became the present business district of that section of the city.

TABLE 2.—DELIMITATIONS OF ZURICH, 1950

Kind of unit	Area (sq. miles)	Population (000's)	Number of Municipalities (Gemeinden)
Administrative-political:			
City of Zurich	34	390	1
State (Kanton) of Zurich	670	777	171
Urbanized area (continuously built up)[1]	38	495	26
Metropolitan area (major commuter area, "Greater Zurich")[2]	100	476	29
Service areas for four levels of central functions:[3]			
Low (2nd) order	112	480	29
Middle (3rd) order	550	680	127
High (4th) order	7,200	2,200	—
Higher (5th) order (all of Switzerland)	16,000	4,715	3,100

[1] W. Schärer, "Die suburbane Zone von Zürich," *Geographica Helvetica*, Vol. XI (1956), pp. 1–46.

[2] Includes all suburban municipalities from which over 25 percent of the gainfully employed residents commute to Zurich.

[3] H. Carol, "Industrie und Siedlungsplanung," *Plan*, Vol. VIII (1951), pp. 191–206.

In the northern part of the city, the spacing of the original villages proved favorable for the development of an especially clear functional pattern (Fig. 4). The village of Oerlikon, which grew to a considerable size on account of its machine factories, became the natural traffic center of that area and consequently the central place for the three neighboring villages of Affoltern, Seebach, and Schwamendingen, which are now also sections of the city itself. Although well connected with the downtown area by public transport lines (railway by means of a tunnel, streetcars and trolley buses), Oerlikon's business district, three miles from the central business district of Zurich, is somewhat isolated. Such a clearly defined situation obviously invites functional research on inner urban centers.

The area of the medieval municipality of Zurich, which is located in the center of the city of today, became the location of the central functions of high order, and thus the central business district. This development had invaded the scantily populated park-and-garden area (the so-called "City"). Later, business buildings encroached upon the more easily accessible, densely built-up residential quarters of the medieval town, thus contributing to a gradual decrease of population from a maximum of 28,000 in 1894 to 15,000 today.

CASE STUDIES ABOUT SERVICES AND SERVICE AREAS

Coming from the airport Zurich-Kloten, a few miles north of the city boundary, and driving through the town to its heart in the South, one would have noticed at the time of the survey a number of distinct business centers (Fig. 4). Seebach, the northernmost business district, is small and shops with common goods prevail. The next, Oerlikon, with its six-storied blocks, its extensive shopping streets, and its bustling traffic, gives the impression of a downtown area of its own. One mile farther south, a small shopping district occupies both sides of the highway. Then, around the Schaffhauserplatz there is a large and well-equipped center. After passing through an area with no shops one enters a quite diversified shopping street which merges into the central business district with its closely built blocks of six-storied commercial buildings, its exclusive shops, and crowded sidewalks.

The various business districts mentioned above along the four-mile north–south route are more clearly marked than business districts in any other cross-section of the city. That is the reason these particular business districts were chosen as case studies for a closer examination of the hierarchy of inner urban central services.

These case studies were done by students attending a practical course in urban geography at Zurich University in 1952–53.[8] Each student chose a particular kind of central service and studied it in one establishment in each of the following three business districts: Seebach, Oerlikon, and downtown Zurich. Two different approaches in studying the individual central functions were chosen: (1) inventory of the amount and variety of goods and services; (2) extent of the service area.

Amount and Variety of Goods and Services

From the first to the second and third of the aforementioned districts, a definite increase in the amount and variety of goods and services can be observed. In the neighbor-

[8] The contribution to this study in form of term papers by the following students deserves to be mentioned: F. Bachman, M. Bronhofer, E. Bugmann, L. Lenzlinger, F. Müller, O. Schläpfer.

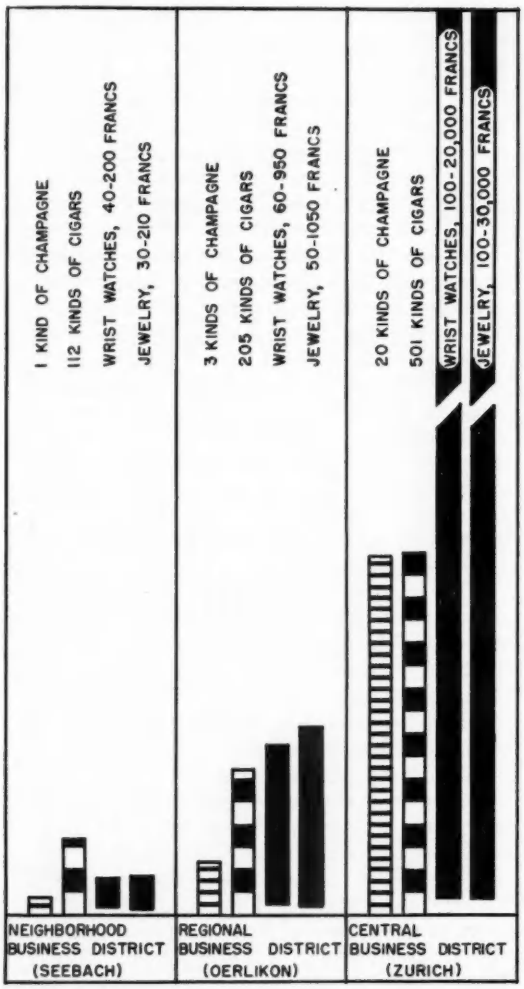

FIG. 1. Range of goods in three business districts of different levels. Each column represents the range of certain goods in a typical store of each center. (Watches and jewelry in the same store.)

hood district of Seebach, only the common goods and services for ordinary household needs are offered; a much wider variety is available in the business district of Oerlikon; but a really exclusive choice is offered only by the shops in the central business district in the heart of the city.

Some examples will serve to illustrate this statement (Fig. 1). One of the students found that the small tobacco-and-stationery shop in Seebach had, among other items, a choice of 112 kinds of cigars; a specialized tobacco shop in Oerlikon offered 205 kinds; while the highly specialized shop at the Bahnhofstrasse in the central business district displayed no fewer than 501 kinds! The price level rises in proportion to the number of different brands offered by the three business districts; e.g., the highest prices per cigar are one franc, two francs, and nine francs, respectively (one Swiss franc = 23¢). (Interestingly enough, the most expensive cigar, worth about two dollars, is generally bought, not by the really wealthy smoker, but by the small employee who wants to live just once like his big boss! King for a day!)

Another student compared a watch and jewelry shop in each of the three selected districts. Wrist watches, for instance, are offered in Seebach in the price categories from 40 to 200 francs; in Oerlikon, in a more highly specialized shop, from 60 to 950 francs. And, in one of the most highly specialized shops at the Bahnhofstrasse no watch was offered for less than 100 francs, while the most expensive ready-made lady's diamond-studded wrist watch was marked at 20,000 francs! In contrast to this shop with its fantastically high price range, a department store at the Bahnhofstrasse offered men's wrist watches for as little as 11 francs. Thus is demonstrated impressively the competitive power of the downtown over all of the lesser business districts.

In the case of food and drink, the general store in Seebach was found to offer just one kind of champagne (to take only one instance), a delicatessen shop in Oerlikon offered three kinds, while one of the most highly specialized shops at the Bahnhofstrasse had a choice of twenty different brands.

Parallel to the number of goods offered in these three business districts, runs the number and kind of other services available. In Seebach, there are a few general physicians; in Oerlikon there are a number of specialists in addition to the general practitioners, while no less than 80 percent of all the specialists practice in or near the central part of the city. The main banks are located exclusively in the downtown area. The more important outer

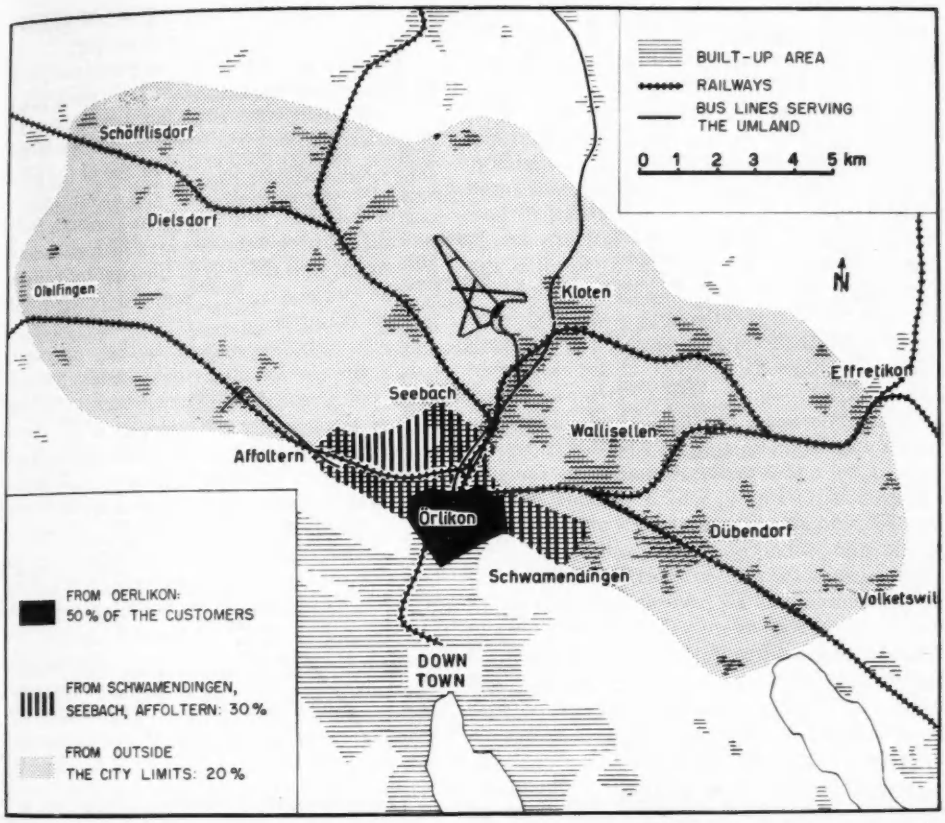

FIG. 2. Service area of a typical shop in a regional business district. Differentiation of a watch-jewelry shop in Oerlikon according to the residence of its steady customers.

districts, such as Oerlikon, have branch banks, while small neighborhoods, such as Seebach, have no banks at all. In contrast to the custom in the United States, the ordinary banking business is done through the post offices; therefore bank branches are not so widespread. Other categories of services, such as cinemas and restaurants, have a similar range in specialized offerings but escape exact classification.

The Service Areas

In addition to classifying the range of goods in selected businesses of the three case centers, the students questioned the owners or managers of the various firms in order to establish their respective service areas.

In the jewelry business, the three case studies revealed interesting facts with regard to the service areas. The small watch and jewelry shop in Seebach draws 80 percent of its customers from the neighborhood of Seebach (13,000 inhabitants) and 20 percent from its immediate neighboring suburban umland, Glattbrugg and Rümlang. The specialized jewelry shop at Oerlikon draws 50 percent of its customers from that same neighborhood, 30 percent from Seebach, Schwamendingen, and Affoltern, and 20 percent from about 25 surrounding municipalities of the rural-suburban umland (Fig. 2). The service area of a highly specialized jewelry shop in the central business district is quite different. Although no figures were available, the manager claimed that not only the whole of Zurich and eastern Switzerland were included in the service area, but, as a result of tourism (a non-central activity), also all of Europe and many

other parts of the world, in particular North America and Southeast Asia, and that the business conducted with foreign customers was assuming major importance.

The small tobacco shop at Seebach draws 50 percent of its steady customers from the nearby blocks, 40 percent from the neighborhood of Seebach, and 10 percent from a small umland outside this area. Only about 25 percent are transient buyers; the rest are steady customers. In the larger shop at Oerlikon, the proportion of transient customers climbs to 40 percent. The service area is divided into: (1) a neighborhood area including Oerlikon, which furnishes 60 percent of the turnover; (2) a larger inner urban area including Schwamendingen, Seebach, and Affoltern, which furnishes 25 percent of the turnover; and (3) a wider umland similar to the one represented in Fig. 2, which accounts for the last 15 percent. The manager of the highly specialized tobacco shop at the Bahnhofstrasse estimates the proportion of his transient customers as 70 percent and that of his steady customers as only 30 percent. Of the latter 60 percent live in the well-to-do areas of the city, 20 percent in the rest of the city and in the suburbs along the lake, and 20 percent in other parts of the state of Zurich as well as in other areas of the country.

The high proportion of transient customers in the highly specialized shops demonstrates the importance of their specific locations, i.e., bordering on the main flow of shoppers. It is therefore evident that these restricted and extremely valuable locations should not be occupied by establishments not directly dependent on the flow of shoppers (e.g., insurance offices or administrative offices).

The general food store at the business center of Seebach supplies chiefly the immediate neighborhood, and, to a lesser degree, the whole of Seebach. Ninety percent of the customers are steady customers. The delicatessen shop at Oerlikon delivers its goods predominantly to inhabitants of Oerlikon, Seebach, Schwamendingen, and Affoltern. The highly specialized shop in the downtown area is estimated to have only about 40 percent of steady customers but 60 percent of transient customers.

Similar conditions were found with regard to the service areas of the physicians in Seebach, Oerlikon, and the downtown area. Here a further element, i.e., the personal qualities of the doctor, plays an important part.

Three large-scale bank corporations (with their head offices in Zurich) extend their activities over the following areas: the city of Zurich, eastern Switzerland, the rest of the country, foreign countries. In one of the three main banks, 70 percent of the investments of one year flowed into Zurich and eastern Switzerland (Zurich's service area of high order), 20 percent into the rest of the country (metropolitan service area), and 10 percent into foreign countries.

For a wholesale firm dealing in cotton goods, the service area covers eastern Switzerland (60 percent of all customers) and the rest of the country (40 percent of all customers), thus placing it at the metropolitan level.

The kind of services offered, as well as the respective service areas, show a striking congruency within the same business district on the one hand, and a clear difference from the other levels of business districts on the other. In other words, these case studies demonstrate a hierarchical order of central services and central places within the city. Although the number of case studies was small, it is justified to assume that they are fairly representative for a great number of similar central services.

How the Three Business Districts are Frequented

To investigate how consumers make use of the central functions of various levels of business districts, one student was asked to study the shopping habits of the population in a section of our study area. The results presented in this report are based on interviews with 92 persons residing in the neighborhood of Schwamendingen, east of Oerlikon. (For location, see Fig. 4). Figure 3 shows some of the kinds of services available and the extent to which the interviewed persons utilized them in the three levels of business districts.

In a first group of services, such as groceries and general medical care, the inhabitants of the immediate neighborhood use their own neighborhood business district (in more than three quarters of the cases). In a second group of services, such as hardware, flowers, and banks, the neighborhood business districts, the regional business district (Oerlikon), and the central business district are

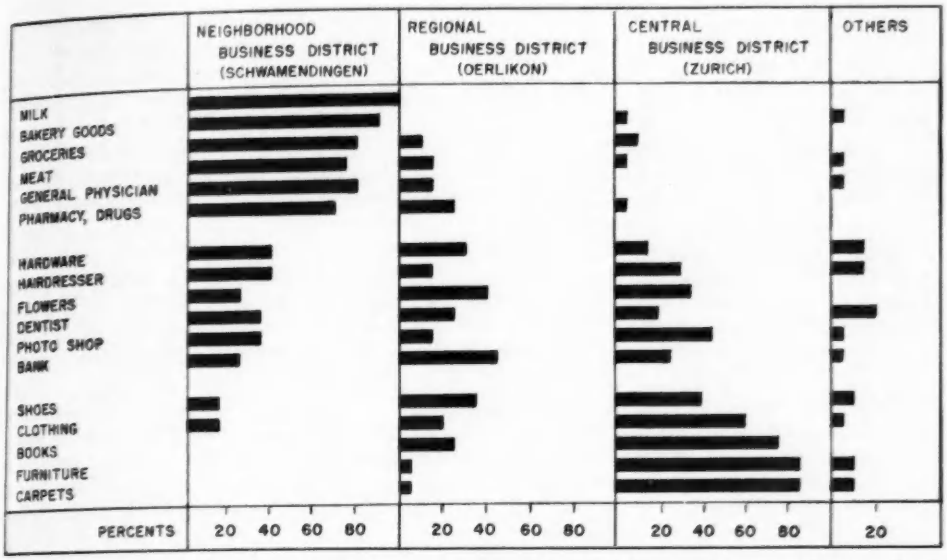

FIG. 3. Percentage of shopping trips made by persons residing in Schwamendingen to the three levels of business districts. For details see text. After T. Trueb, "Raumbeziehungen der Einwohner stadtzuercherischer Quartiere," manuscript, Department of Geography, Zurich University.

about of equal importance. For a third group of services, such as books, clothing, and furniture, the central business district is used predominantly, namely, in 60 to 80 percent of the cases.

THE BUSINESS DISTRICTS OF THE CITY

The case studies displayed in some detail above led to a fuller understanding, to comparison, and to classification of the central functions. By studying the distribution of the various central services according to their levels over the whole city, a hierarchical classification of the central places was arrived at. Four distinct levels can be distinguished: local business district (lowest order), neighborhood business district (low order), regional business district (middle order), central business district (high order).[9] The lowest order of the hierarchy, representing a cluster of a few round-the-corner shops, is not taken into consideration here; the other three are discussed below.

In the typical neighborhood business district only the kind of goods which are in quite frequent demand can be bought. Of all existing services in such a center, the following are characteristic for this order: watches–jewelry store (of that particular level); photography–optician stores; electrical equipment and radio stores, hardware stores, bicycle stores, flower stores, *Drogerien* (not as diversified as an American drugstore), *Apotheken* (corresponding to a specialized pharmacy), tobacco–stationery stores, shoe stores, post office, general physicians, and dentists.

Situated towards the periphery of the city's built-up area, a typical center of this order supplies some 5,000–10,000 inhabitants. On the city map (Fig. 4), 20 isolated neighborhood business districts can be distinguished inside the city boundaries. A more detailed survey, however, would have to establish subcategories in order to represent existing conditions more faithfully. As it is, some of the business districts would fall in between these broad categories, while others have emerged since the survey was made.

The typical regional business districts supply services of middle order for their own neighborhoods as well as for the surrounding

[9] M. J. Proudfoot's terms as used in his article on "City Retail Structure," *Economic Geography*, Vol. XIII (1937), pp. 425–28, proved suitable for the designation of these four levels. The results, however, were arrived at independently in the Zurich research.

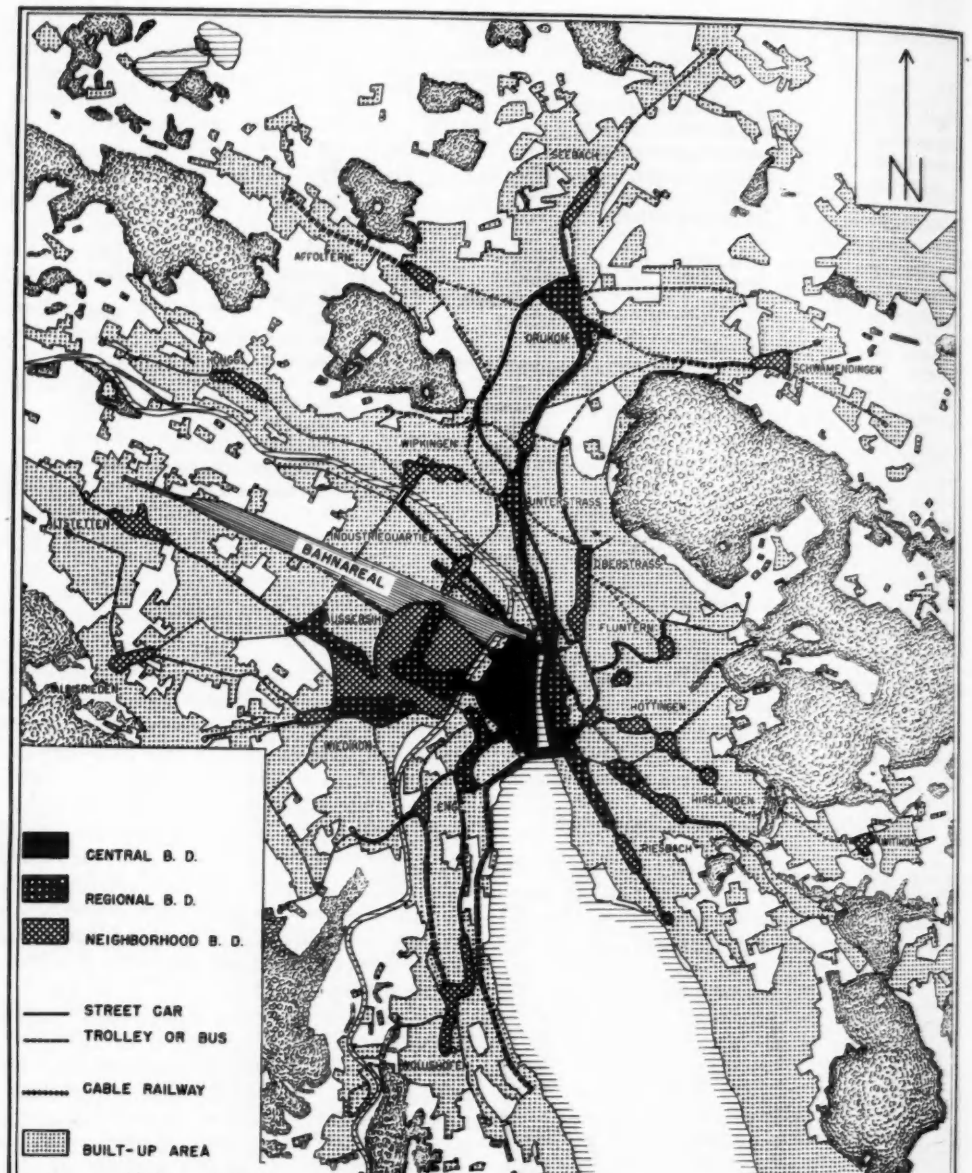

FIG. 4. The business districts of Zurich. The classification is based on the distribution of retail facilities, not including other central functions.

neighborhoods, while, of course, also offering services of low and lowest order predominantly for their own neighborhoods. Oerlikon provides a good example. As demonstrated above, its services supply Affoltern, Seebach, Schwamendingen, as well as Oerlikon itself, altogether a population of about 60,000 at the time of the survey. In addition, at least part-

ly, it serves an industrial-suburban-agricultural umland outside the city boundaries containing about 30,000 inhabitants. The following central services have (in addition to the services of the level of the neighborhood centers) proved to be typical for the regional business district: specialized watch-jewelry stores, specialized tobacco stores, specialized opticians, delicatessen stores, furniture stores, radio, record, and musical instrument stores, leather goods stores, sewing machine stores, fur stores, millinery stores, fashion stores, book stores, bank branches, medical specialists, lawyers, and cinemas. A variety of services unsuitable for classification are not listed here (e.g., artisans, cafes, and restaurants).

Ten business districts inside the city boundaries were found to provide the above listed central services, characteristic of middle order, and are thus classed as regional business districts. Five others were isolated (Fig. 4). In 1959, Altstetten and some other neighborhoods reached the level of regional business districts as a result of a strong population increase in the service area.

The central business district is characterized by the fact that it serves the whole of the city and the city's umland of middle and high order, while its metropolitan services (of higher order) cover the whole of Switzerland. The middle, and more particularly the high and higher services, represent one group of the basic economic functions of the city. The central business district will be discussed more specifically later on.

The Flow of Pedestrians

The classification of the business districts according to the level of their central services was checked by another method. Casual observation of the various districts showed a correlation between their respective levels and the number of people crowding its streets. Thus, counting the number of potential customers may provide an easy quantitative method of classifying business districts. To eliminate the idle passers-by as far as possible from the number of potential shoppers, the counting should take place in the middle of the afternoon when most people are not going to work or returning. Counts should be made under unpleasant weather conditions to lessen the chance of including mere window shoppers.

Encouraged by the result of a test in 1952, a large-scale simultaneous count all over the city's centers was undertaken on a chilly November day in 1953. One hundred and fifteen persons, consisting mainly of high school boys, were posted at 45 different locations. Despite the many potential sources of error inherent in this method, the results (Fig. 5) showed very clearly three distinct groups of pedestrian flow which correspond closely to the qualitative classification of the central places shown before. In the central business district (central section of the Bahnhofstrasse) there was at that time a pedestrian flow of 4,480 persons per hour; in the regional business districts, 700–1100; in the neighborhood districts, 200–450. In the streets adjacent to the business districts the number dropped to a small fraction of the figures for those districts.

A synthetic approach to the hierarchical pattern of central functions should not only show the central *places* of various levels (as demonstrated in Fig. 4), but it should contain their respective *service areas* as well. Service areas can be delimited in two ways: (1) inquiring about the service area of individual central services through the managers of such establishments; (2) inquiring through the consumers of those services. Both methods were used; however, to conduct such a time-consuming investigation over the whole city was beyond the scope of the present study.[10]

Practical Considerations

This kind of study is not of academic interest only; it may help to solve practical locational problems for central services; a businessman who has decided on the level of the service for his business-to-be should be aware of the fact that the optimal locations for his enterprise are of a limited number already defined by the number of existing or potential centers. The city planner who is developing new neighborhoods will have to bear in mind the importance of a well laid-out street system focusing at a specific center, while also thinking of the relationship between the population of the future neighborhood and the size of the corresponding business district.

[10] A more detailed investigation into this matter has been assigned as the subject of a dissertation at Zurich University.

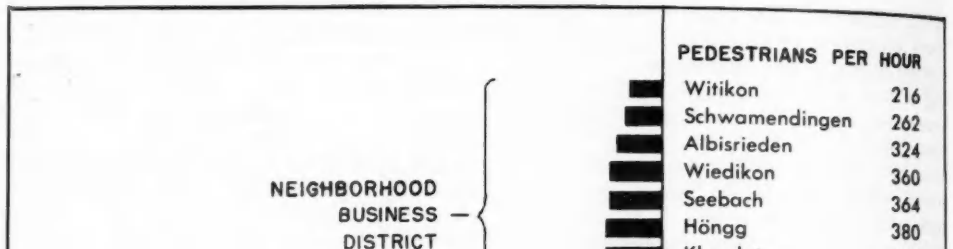

FIG. 5. Pedestrian flow in selected business districts of the city.

Well-established business districts reflect the interest of the customer as well as of the businessman. The one enjoys the advantage of a short distance from home to shop, multiple purpose shopping at the same center, as well as a large choice and keen competition; the other profits by the largest possible number of potential customers. It is obvious that the best integration of business district and service area can be achieved in completely new towns (e.g., the British New Towns).

To mention another example: The problem of what would happen if Oerlikon's service area should double in population was discussed. Some city planners were of the opinion that in this case the present business district would develop into a second central business district, making Zurich a city with two nuclei. This reasoning was based on the fact that Oerlikon as well as the downtown area is mapped in the category of commercial land use. This argument, however, does not take into consideration the great difference in the *levels* of business activity between the two business districts. There appears to be no reason for a pronounced shift of the central services of high order in the future, because today's downtown area lies in the present as well as in the future traffic center of the city, and of the umland of middle and high order as well. The rail system is fixed, and the new national highway system with its expressways will support the existing pattern. Thus it seems highly probable that the present central business district will maintain its superiority over the business district of Oerlikon, even though the latter will also continue to grow.

THE CENTRAL BUSINESS DISTRICT (CBD)

The CBD was previously defined as the location of all kinds of central services which supply the whole rather than only a section of the city. A concentration of all the higher functions of a city occurs at this restricted spot because of the four main advantages it offers:

(1) No other location is as easily accessible for all inhabitants of the internal and external service areas. It is the meeting place of radial train and road connections from a wide umland as well as of the city transport

system. It provides the best access for motorists from every part of the city and the tributary area (if the necessary parking space can be provided). The CBD is therefore the best location for retail firms and offices which are dependent on a large selection of customers from all over the service area.

(2) The CBD offers the businessman close contact with his business friends, and easy access to auxiliary businesses, such as banks, post offices, suppliers of goods and services.

(3) The CBD provides easy access to the city's labor force. No other location can be reached as easily by employees from all over the metropolitan area. An employer offering a post in the CBD has therefore a wider choice of potential employees than a similar employer outside the downtown.

(4) The established CBD provides for an attraction for all new activities.

However, these advantages are somewhat diminished as a result of the increase of private transportation. Certain businesses which used to be tied to the downtown area may now find more suitable location outside the congested and expensive CBD area. But this tendency towards decentralization is counteracted by the vigorous attempts at solving the downtown traffic and parking problem. This problem, though not as urgent as in the United States, is assuming a rapidly increasing importance in Zurich as well as in other European cities with the additional complication (as in Zurich) of a medieval city-core which, on account of its historical and aesthetic value, obviously must not be sacrificed in order to obtain more parking space.

General CBD Functions

For all urban studies, it is vital to know the actual extent of the CBD area. Besides being a major issue in the functional studies of urban geography, it is as important a question for the businessman in search of an appropriate location for his enterprise within the CBD. The impulse for the present study came, as a matter of fact, from such a demand. For reasons of urban renewal, a large department store had to find a new location. The research department of that firm, afraid that the firm might be pressed by the city to build in an unfavorable location, asked me to define the city's core, and to differentiate the area with

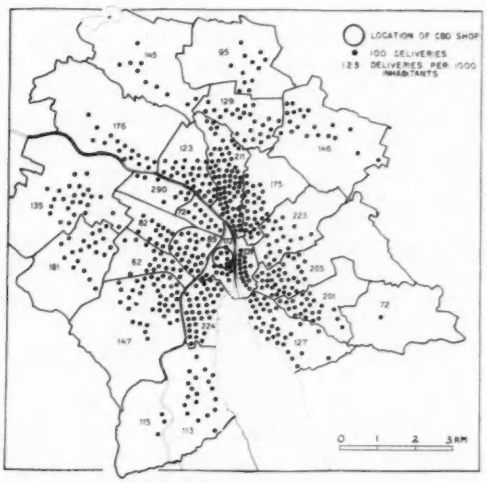

FIG. 6. Service area of a CBD shop. Deliveries outside the municipal boundary are not shown.

regard to its locational qualities for department stores.

The central functions of high order have the strongest centripetal tendency, stronger than either housing or manufacturing. Competition makes for the highest rents and the highest land values. In the peak value zone of Zurich's Bahnhofstrasse 8,000–12,000 francs were paid for one square meter, equaling 200–300 dollars per square foot, not considering the building value and the higher purchasing power of the franc compared with the exchange rate.

It was said before that the CBD is characterized by a concentration of higher central functions. This statement holds true for the great majority of such functions. Some of them, however, are so space-consuming, or have other locational requirements, that they cannot be incorporated in the center of a city. This applies to airports, railway stations, hospitals, schools for higher education, wholesale storage, etc. In Zurich some of these functions touch the CBD; others are far away. In this study all central functions which have a strong tendency of being located in or near the center of the city are called CBD functions.

The delimitation of the CBD can be arrived at through the following steps: (1) distinguishing the CBD functions from non-CBD functions; (2) mapping these two groups in

the central area of the city; (3) delimiting zones of similar character.

Theoretically step 1 would imply an inquiry into the individual service area of every establishment in the central parts of the city. Those serving the whole city, or even a larger area, would be considered CBD functions (Fig. 6); those serving only a part of the city, non-CBD functions. A map which would show the location of all CBD functions would reveal an almost solid core of such functions surrounded by a zone of scattered CBD functions decreasing outwardly in density.[11]

Although in theory the principle is easy and clear enough, practical considerations prompted a simplified method. Establishments of the same kind (i.e., offering a similar range and variety of goods and services, and having most likely a city-wide service area) were considered collectively as belonging to the same category. The establishments of the following categories were found to be general CBD functions: highly specialized shops, large department stores, main offices or branches of associations, import-export firms, offices of wholesale distributors, insurance headquarters and certain branch offices, head offices of local banks, branches of other banks, the stock exchange, commercial offices of factories which are located outside the city, offices of medical specialists, offices of lawyers, offices of architects and engineering firms, administration of city, state (Kanton) and federation, professional schools, cinemas (with specialized programs, or of very large size), opera and playhouse, cabaret-theaters, conference and concert halls, hotels, restaurants and bars (of specific kind).

This qualitative selection had to be followed by a quantitative estimate of the amount of space occupied by such CBD functions. Each building unit was classified under one of the following categories:

(1) *CBD buildings*: three or more floors are occupied by CBD functions;[12]

(2) *semi-CBD buildings*: one or two floors are occupied by CBD functions:

(3) *non-CBD buildings*: less than one full floor is occupied by CBD functions.[13]

Each building unit was mapped according to one of the three categories on an urban property map (scale: 1:2500). After some experimentation the method proved to be sufficiently accurate for the purpose it had to serve, while, of course, there is no doubt that a time-consuming investigation of the individual firm would increase the accuracy of the results.

Such an investigation would have to be based on interviews or questionnaires determining for each establishment (1) the kind of function it performs, (2) the areas it serves, and (3) the floor space or the building volume it occupies. The second question could be combined with a question designed to find out to which proportion the establishment's

[11] At this point some remarks on the Murphy–Vance studies have to be made (*op. cit.*). By a curious coincidence I happened to be doing my field work in the downtown of Zurich at the same time that R. E. Murphy and J. E. Vance began their famous study of the CBD of nine American cities (September–October 1952). However, I did not know of their study until it was published in 1954–55. The approach in delimiting and differentiating the CBD by the Murphy–Vance method has similarities and differences in the following major points, as compared with the Zurich study: (1) Murphy and Vance decided that the "really essential business functions appeared to be the retailing of goods and services for profit and the performing of various office functions" (also for profit). These establishments "serve the city as a whole rather than any one section or any one group of people." In this sentence the central place concept finds its expression. However, the study did not follow this line of thought further as a theoretical or practical basis for the decision as to what are and what are not CBD functions. (2) Consequently, all commercial business land use is taken into consideration by the Murphy–Vance method, while in the Zurich study exclusively central functions of middle and higher order (commercial, administrative, and cultural) are considered to be characteristic of the CBD. (3) The Murphy–Vance method aimed at the comparative study of the CBD's of nine American cities. Therefore, a practical set of techniques and standards had to be devised which indeed produced an unmatched amount of detailed knowledge about the CBD. The Zurich study, on the other hand, focussed at the application of the central place principle for the internal differentiation of one city. It remains to be seen, however, if the Zurich method would lend itself to exact comparison as well as the Murphy–Vance method.

[12] The building height is limited by law in the central area of the city to six stories, which means that 50 percent or more of the building space is occupied by central functions of high order; most business buildings are used exclusively for such functions.

[13] In the field work, classification under CBD functions or non-CBD functions was based on the kind of goods displayed in the shop windows. For offices, it was decided by the firms' door plates. Usually, the amount of space occupied within the buildings could be estimated from their outer appearance.

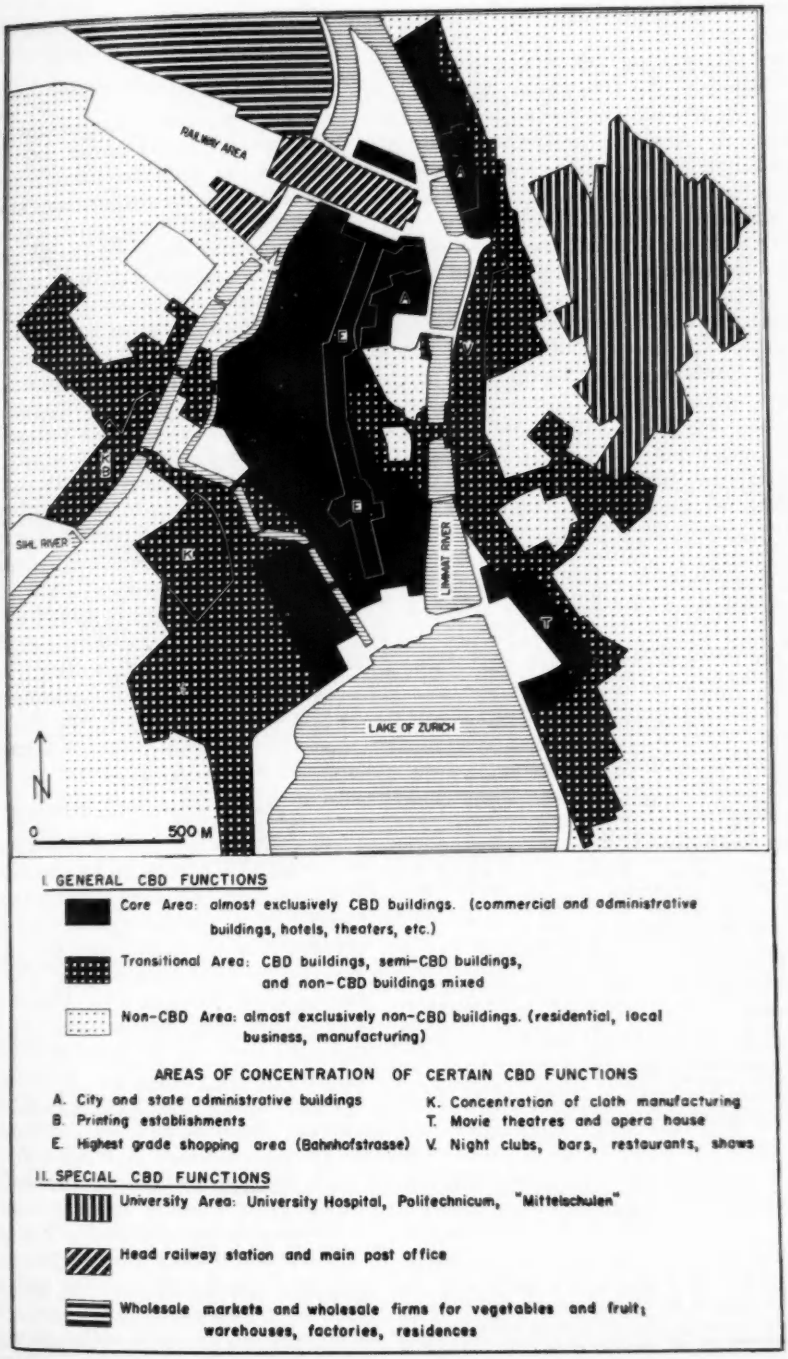

FIG. 7. The central business district of Zurich.

functions are basic and to which they are non-basic.

The area consisting almost exclusively of CBD buildings is the core of the CBD (Fig. 7). The Bahnhofstrasse and the so-called "City" (i.e., the newer business district) make up the main part of the nucleus (43 hectares). The transitional area comprises a mixture of CBD buildings, semi-CBD buildings, and non-CBD buildings (59 hectares). Non-CBD buildings interspersed with occasional CBD buildings form the non-CBD area.

Certain general CBD functions are concentrated in specific sections of the downtown (Fig. 7): highest grade shopping: Bahnhofstrasse; administrative areas: Walche, Werdmühle, Stadthausquai; theater center: Bellevue; night clubs and bars: Niederdorf; printing center: Stauffacherquai; clothes manufacturing: Selnau and Stauffacherquai.[14]

Special CBD Functions

Apart from general CBD functions, three zones of special CBD functions were delimited:

(1) The head railway stations (as well as the main post office) is located extremely favorably, at the edge of the CBD: 130,000 persons move in and out by train every day, including about 20,000 commuters.

(2) Connected with the railway area by a special siding lie the wholesale markets and wholesale firms for vegetables and fruit. In addition, warehouses of CBD firms, manufacturing and residential functions occupy a considerable part of this zone.

(3) The lower terraces and gentle slopes of the Zürichberg are the seat of higher education: of the Federal Polytechnicum (ETH) and the University of the State of Zurich with its large university hospital, and of the "Mittelschulen." The central position of all these educational establishments is of great advantage to their students because the total student body of 5000 at the university and Polytechnicum do not stay in dormitories but predominantly come daily from all parts of the city and its wider umland.

The Exclusive Shopping Location

Of all these different zones into which the CBD can be divided, we may look more closely at the most popular and most prominent area: the Bahnhofstrasse. As a result of a strong demand for space in the best selling area, rents and land prices reach peak values. Here the luxury shops, such as jewelry and fashion shops, and many other kinds of high-class establishments, form an almost continuous line. The artistically displayed, high quality goods make the Bahnhofstrasse one of the famous shopping streets of Europe. In addition, three of the four large department stores of the city tap the strong flow of pedestrians in the Bahnhofstrasse. The yearly average varies, according to the size of the stores, between 5000 and 25,000 customers a day, while peak figures reach as high as 75,000 persons per day! No other location in the city could attract such large numbers of customers. Such a shop offers something like 400,000 different kinds of articles.

Careful mapping of the actual distribution of true CBD shops all over the downtown areas led to the evaluation of zones of similar selling potentialities (Fig. 8).

The Flow of Pedestrians

An independent method, counting the flow of pedestrians, proved to be a useful check on the results of the shop classification. On an unpleasant afternoon in early December 1952 student teams counted 5844 pedestrians per hour in the peak value area of the Bahnhofstrasse (Fig. 9). The second most important shopping streets, the Rennweg and the Limmatquai, were in the level of 2000 to 2500 persons; other important locations in the downtown had 500–1000 persons while the number dropped to a few hundred towards the periphery of the CBD. Not only within the CBD, but also within the Bahnhofstrasse, a strong differentiation in the pedestrian flow was found as demonstrated in Fig. 9.

As a result of these investigations, some *general conclusions* can be drawn with regard to the factors driving the shops to the best location, near to the peak value section of the CBD. It becomes essential for a shop to reach the strongest flow of pedestrians if the shop is

[14] Clothing and printing industries are very important in Zurich. They are located closer to the core of the CBD than any other manufacturing industry because they need the intimate contact with the economic *and* cultural life of the downtown. Today I would be inclined to put them into the category of special CBD functions.

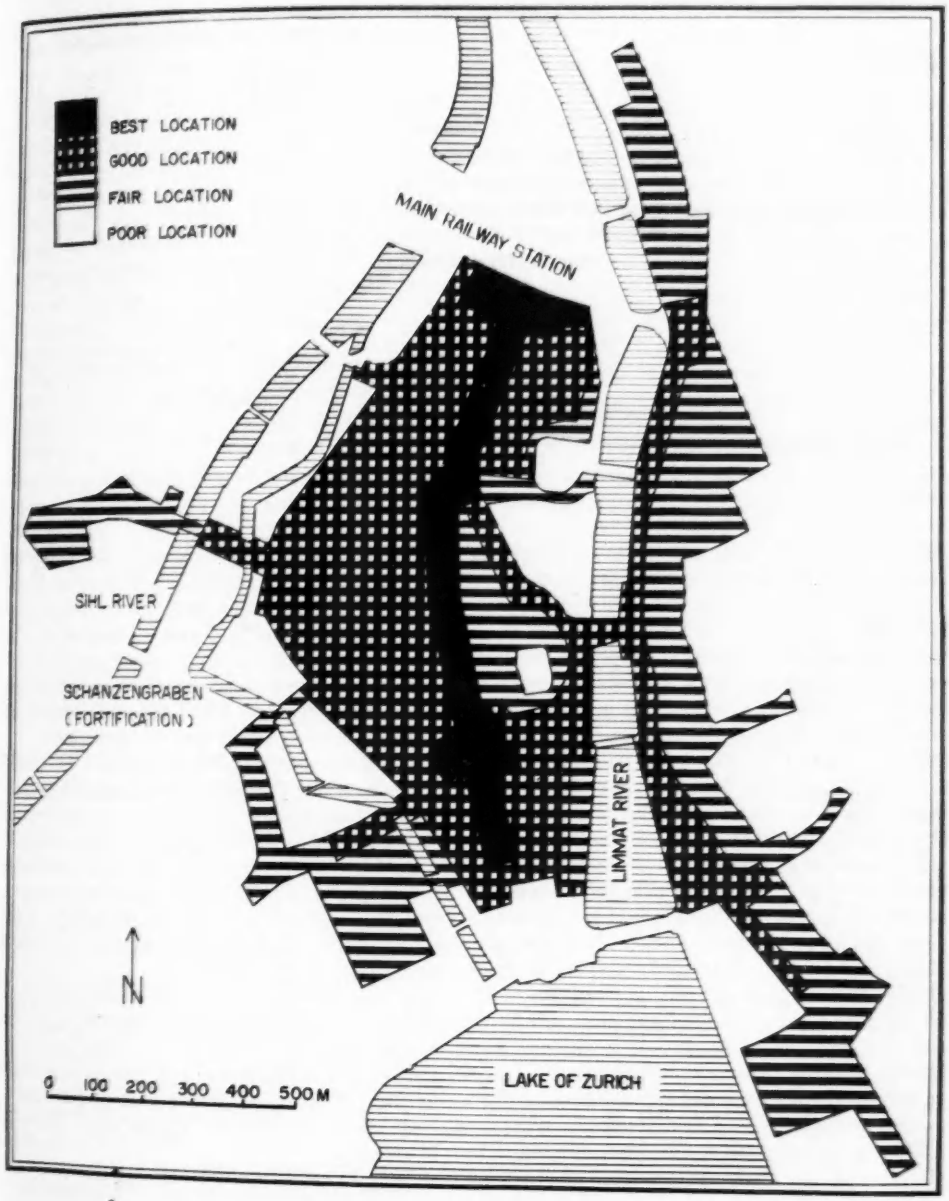

FIG. 8. Zones of similar selling potentiality within the CBD.

dependent on one or more of the following criteria: (1) the group of transient customers is of chief importance; (2) the window display is of a major attraction to the customers; (3) the profits from sales of goods per unit of shop volume is high (jewelry as opposed to furniture or household machines); (4) the shop offers highly specialized goods; (5) the number of customers necessary for maintaining the shop is very large (department stores);

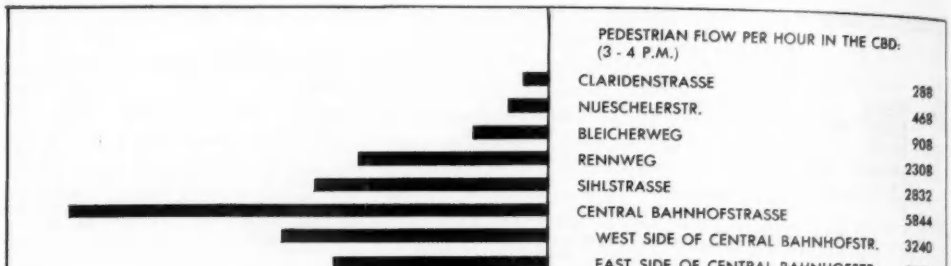

FIG. 9. Pedestrian flow within the CBD.

(6) the business depends on the prestige of being located in the best shopping area.

Evolution and Future of the CBD

In the foregoing analyses emphasis was put on the description of the present patterns in the downtown area. For a full understanding of the city's core one should study it dynamically, including the time factor, and describe and explain how its pattern came about. One would have to start with the still medieval conditions at the beginning of the 19th century; show when and why the walls and towers were torn down, why the main shopping street of that time, the Rennweg, was taken over by the Bahnhofstrasse (built in the 1870's); why the villas and gardens west of the Bahnhofstrasse had to give way gradually to the CBD (a process which was completed only in the business building boom after World War II); why recently business blocks took over the area west of the Schanzengraben (outside the medieval fortification); why the CBD expanded over the fashionable residential area of the Enge west of the lake ("zone of assimilation"); why, on the other hand, the development is hesitant to encroach upon a lower grade residential and industrial area to the west of the Sihl River ("zone of discard"); why the slopes of the Zürichberg prevent large-scale development; and why the geometrical center of the downtown is a non-CBD area.

Today, there is a strong tendency to use up the space west of the Sihl, near the core of the CBD. It would seem to lie in the scope of a far-sighted planning board to encourage the reservation of the area near the actual CBD exclusively for future expansion of the higher central functions, which, after all, constitute Zurich's most genuine basic functions.

It emerges very clearly from the CBD study that the plans for a tangential set of expressways around the core of the city, which are being worked out at this time, are very reasonably conceived. The western expressway planned along the Sihl River is truly tangential to the hard core of the CBD; it would have to be joined by expressways to the east and south of the CBD.

If the traffic problem is solved (presumably by establishing parking garages along the tangential expressways), it seems probable that the Bahnhofstrasse will maintain its rank as the first-class shopping area in the future, because of its locational advantage in the very heart of the city.

WILL AMERICAN-TYPE SHOPPING CENTERS INVADE EUROPEAN CITIES?

If we glance once more over the whole city, we find its pattern of central functions changing in various degrees. In the expanding outskirts of the city, where the demand is for new central functions, new business centers are being created. Older centers have to be

enlarged to meet the demand of growing populations in their service areas. Even the downtown area itself is in a stage of expansion and transition. Will this development of the last few decades be the trend for the decades to come? Or will new habits, such as car-shopping, bring about revolutionary new trends such as the new-type shopping centers of American cities? These questions were discussed in an international congress which was held near Zurich in 1957, and which was concerned with the shopping center in Europe.[15] As a result of this congress, private enterprise has been busy studying new opportunities for investment. I was asked to report on the general problems of establishing car-shopping centers in Switzerland, and also to select possible locations in the Greater Zurich area. However, at the end of 1959 no such shopping center had yet been constructed in Switzerland.

There are a number of reasons why the American type of car-shopping center has not yet spread to Europe: (1) The mobility provided by private cars is less pronounced and public transport is generally very efficient. (2) Few households have large refrigerators and deep freezers for storing a large supply of food. (3) The residential density in suburban areas is generally much higher in Europe than in the United States. Even in suburban areas the shops supplying food are so conveniently located that the housewife can do her daily shopping on foot. (4) Land prices are much higher in relation to the standard of living, thus discouraging the use of vast areas for parking space. (5) There has been an organic growth of the suburbs around already existing village centers.

The last three points in particular contrast to the conditions in many of the newer American suburbs, created by the tremendous postwar boom in housing. During that era, private builders spent little thought on an integrated development. Generally, community services and shopping facilities were lacking for the vast sprawl of suburban houses. This need has been filled by the new type of shopping centers. Considering further the traffic congestion in the downtown areas, shopping centers have proved to be a real blessing to American cities.

Similar conditions of widespread, disorderly growth do, no doubt, exist in certain parts of the larger European cities as well, and here the American type of semi-integrated shopping center will undoubtedly solve the problem. Generally, however, as has been indicated above, European cities grew up more organically and also more compactly than American cities. Particularly since World War II, attempts have been made everywhere throughout Europe at a fully integrated urban expansion. Examples like Vällingby, a planned satellite of Stockholm, with a fine shopping center in its core serving 60,000 inhabitants, the rebuilding of Rotterdam, and particularly the eight "New Towns" of Greater London, lead the way to new forms of metropolitan development. In the "New Towns," three levels of business centers are completely integrated into the fabric of the settlement, providing optimal services for its 50,000 to 80,000 inhabitants.

In the Zurich area too, such ideas are beginning to be put into practice. Private or cooperative builders of new housing estates have provided them with shops for the daily needs. Recently, a whole neighborhood was built, containing residential housing of one, four, nine, and eighteen stories, playgrounds, schools, a post office, and a carefully selected set of a dozen shops. Five thousand to 10,000 potential customers live within a few minutes' walking distance from this fully integrated shopping center. For the comparatively few car-shoppers more adequate parking space should be provided.

For Zurich as well as for other cities, the future for the location of central functions lies in this kind of well-integrated urban development. In the downtown area an even stronger specialization in the category of higher central functions will take place, relegating the lower-level services to regional and neighborhood centers. Great efforts will have to be made to insure that all centers are easily accessible from their service areas by private and public transport, and this principle should be applied particularly to the central business district. For here the preservation of the unique values which the core area offers to the economic and social life of the city is at stake.

[15] *Das Shopping Center in Europa*, Stiftung "Im Grüene," Rüschlikon (Zürich, 1957).

CONCLUSION

The objective of this study was to apply the concept of central functions not only to the city–umland relations, as was done previously, but specifically to the internal differentiation of the city. The concrete work was carried out in the city of Zurich, Switzerland. Seven points of general interest may be summarized:

(1) Here, as well as in my studies on town–umland relations, the absolute (not the relative) centrality was chosen as the basic criterion for classification. Three methods of determining central functions and their service areas were utilized in a series of detailed case studies: (a) field investigation into the kind and variety of goods and services; (b) interviewing the managers of the central services regarding the extent of the service areas; (c) interviewing the population about their use of the central services.

(2) On the basis of the above field investigations, the central services, the central places, and the service areas could be ranked into a hierarchical order of seven main classes. Of these seven orders, the services of the second, third, fourth, and fifth order were examined in the Zurich study.

(3) For Zurich, three major levels of central places were distinguished: neighborhood business districts (second order), regional business districts (third order), and the central business district (fourth and fifth order).

(4) The central business district is defined as that area in which the highest central functions of the specific settlement are located. These functions are characterized as serving the settlement as a whole (and possibly its umland) rather than only a part of it. The central business district incorporates not only commercial, but also administrative and other central functions. The term "central business district" does not apply to a specific order of central functions; on the contrary, it may occur on all levels, from the second to the sixth. For instance, the CBD of a small town may be composed of central functions of second order while the characteristic central functions of the CBD of New York are of fifth and sixth order. The CBD of Zurich is dominated by central functions of fourth and fifth order.

(5) This study demonstrates that Zurich is an example of a fairly well-integrated European city — undamaged by war and not yet strongly influenced by the private car era. It proves also that the macrocosmic spacing of central places over wide areas finds its counterpart in the microcosmic organization of business centers within the city.

(6) Studies of the pattern of central functions within the city are relevant for the solution of a number of practical problems, such as: (a) helping the retail business man who is seeking new locations; (b) planning new business centers which are fully integrated in the pattern of expanding suburban settlements; (c) establishing semi-integrated American-type shopping centers in areas where urban sprawl has already gone beyond well-organized expansion; (d) zoning for future expansion of the central business district; (e) intelligent planning of expressways so as to enhance the functioning of the city's core, that is, locating expressways tangential to the central business district; (f) laying down principles for the planning of "new towns."

(7) In this survey the classification of central functions and central places is based primarily on *qualitative*–comparative techniques; it is felt, however, that further research should be invested in the problem of a *quantitative* classification.

LOW-VALUE HOUSING IN TWO NEW ZEALAND CITIES[1]

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THE comparative youthfulness of European settlement in New Zealand, and the relatively recent growth of its towns and cities, are well appreciated by New Zealanders. They are far less conscious, however, of the increasing problems associated with maturity and old age in their urban settlements. New Zealanders tend to see only the recent signs of vigorous urban growth: the transformation of pasture, orchard, and market gardening land into broadly uniform and extensive districts of new suburban housing; the aggregation of new suburban shops, offices, factories, and used-car lots along the main arterial streets; and the construction of modern motorways leading into some of the urban areas. In general, the urbanized New Zealander fails to look for, or to recognize, the evidence of advanced maturity in his large cities: decay in the older residential districts; traffic congestion in the streets; and the destructive spread of the central business districts. It is probably true to say that because he is uninformed about the physical decay in the urban fabric, if not indifferent to its onset, he gives little active support to, and exerts even less pressure on, the national and local authorities whose legal responsibility it is to see that minimum housing standards are maintained. As a result little attention has so far been given to the definition and clearance of poor-quality housing areas.

Urban conservation programs as such do not exist in New Zealand. Under present legislation slum conditions must exist before a "reclamation area" can be defined in law and action taken to improve the affected neighborhood. There is also no mechanism by which the government can make loan money available for home improvements; in fact, the national mortgage agency of the New Zealand government (the State Advances Corporation) is empowered to lend money only for new housing, thereby forcing purchasers of older houses to arrange mortgages at higher rates from commercial lending institutions. The whole tenor of contemporary legislation in New Zealand reflects the definite lack of awareness that age and decay are catching up with the older parts of the larger cities. People forget that several of their cities are now more than 110 years old.

The islands of New Zealand were settled mainly by colonists who came from Europe after 1840. In that year the North Island settlements of Wellington, Wanganui, and Auckland were founded, Wellington and Wanganui being established by the New Zealand Company as colonial base towns from which the surrounding forest lands could be settled, and Auckland being laid out on the initiative of the British Governor as the capital city of the Colony. During 1841 two more colonizing centers were founded, one by the New Zealand Company at Nelson, in the South Island, and the other by the Plymouth Company at New Plymouth, in the North Island. Kororareka (now Russell) in the northern Bay of Islands predated these settlements by several years. European, Australian, and American traders, sealers, and whalers made this northern Maori village notorious in the Pacific. The village was also a valuable early center of maritime trade. Additional colonial settlements were founded in the South Island by other special land companies at Dunedin, in 1848, and at Christchurch, in 1850. Thus, by 1850 the four future metropolitan cities of New Zealand had been established: Auckland and Wellington in the North Island, and Christchurch and Dunedin in the South Island. One hundred and six years later they had grown into cities with populations of 381,000 (Auckland), 138,300 (Wellington), 193,300 (Christchurch), and 99,400 (Dunedin).

Some, but by no means all, of the cottages erected in the first decade of urban settlement have been replaced in the metropolitan cities by business premises, as the central business districts have expanded; less frequently they have been replaced by newer houses. Many pockets of small cottages still remain, how-

[1] This study was made possible by a grant from the Research Grants Committee of the University of New Zealand and by the cooperation of the Valuer-General, officers of the Valuation Department, and officers of the several local bodies in Christchurch and Dunedin, to whom grateful acknowledgment is made.

ever, in the older, inner districts. Most of these early cottages were simple, single-story buildings of weatherboards and interior wood lining. During the last century frame houses continued to predominate in almost all New Zealand towns although there were some regional differences in the materials used. One of the more notable exceptions was Dunedin where brick and concrete construction was always extensively employed, and where several lines of rowhouses were built on the pattern of Industrial Britain of the nineteenth century. Many of these are to be found today in the inner areas of Dunedin. The typical house in New Zealand, though, has been the independent, single-story frame building set on its own lot. These wood buildings have only a limited life.

In general, the average life of a wood house in New Zealand is considered to be 80 years, although the rate of decay varies considerably according to the quality of the original building and the amount of maintenance. For this reason no direct relationship can be drawn closely between the age and the condition of a house. Nevertheless, the fact remains that many thousands of the present houses in the four metropolitan cities of New Zealand were built 70 or more years ago. At present no census data are published on either the age or the physical condition of New Zealand houses; however, a study of the censuses of population suggests that probably 14,000 new houses were needed in the four main cities between 1871 and 1881 to cope with the increased population, and an additional 28,000 were required between 1881 and 1891, assuming a modest density of 5 people per house. These houses would be between 70 and 80 years old today. A considerable number of them are still standing in the main centers; some of them have several years of useful life remaining; but even a brief critical examination of the older residential districts shows that many are now at the point where they need, or will very soon need, replacing altogether. They have very little economic value today. Some of them are slums. Their existence poses an interesting problem in applied geography. How many houses are already in the low-value category; where are they located within the cities; and by how many will their number increase (or decrease) in the future, if present economic conditions, legislation, and community attitudes continue to prevail? These questions are the subject of the present paper.

METHOD OF STUDY

Probably the most effective method for delimiting the quality of houses is that developed by the American Public Health Association Committee on the Hygiene of Housing.[2] This method requires that data relating to the condition of dwellings and neighborhood environments are collected by inspection in the field. Penalty scores are assigned for housing and neighborhood conditions that do not reach a reasonable standard. Residential blocks are graded according to their deficiency score. This is far too expensive a method with which to find an answer to the general problems posed here. It is also unlikely that any community in New Zealand today would meet the costs involved in a wide-scale and detailed field survey of the incidence of poor-quality housing. Yet in 1937, in the first flush of election to office and with the fresh memories of the depression years behind it, the government had a survey of housing carried out in the main cities.[3] The work was done by health officers of the respective urban authorities. The number of units included in this survey varied from city to city but it was generally not large, totalling approximately 8,500 in Dunedin and 5,250 in Christchurch. The code of satisfactory standards was defined by the government in rather general terms. The survey itself revealed the unsatisfactory condition of many of the houses in the inner residential districts. Sixty percent of the houses surveyed in both Dunedin and Christchurch were found to be unsatisfactory in some respect. When the Second World War broke out in 1939 the whole program of a national housing survey was put aside. It has not been revived, even though the need for an adequate survey has increased during the 22 years that have elapsed since it was first started.

The method employed in this paper for measuring the present incidence of low-value

[2] American Public Health Association, *An Appraisal Method for Measuring the Quality of Housing* (New York, 1945–50).

[3] Reports on the Housing Survey of 1937 by the city councils of Dunedin, Christchurch, Wellington, and Auckland (unpublished, but filed in the Ministry of Works Library, Wellington).

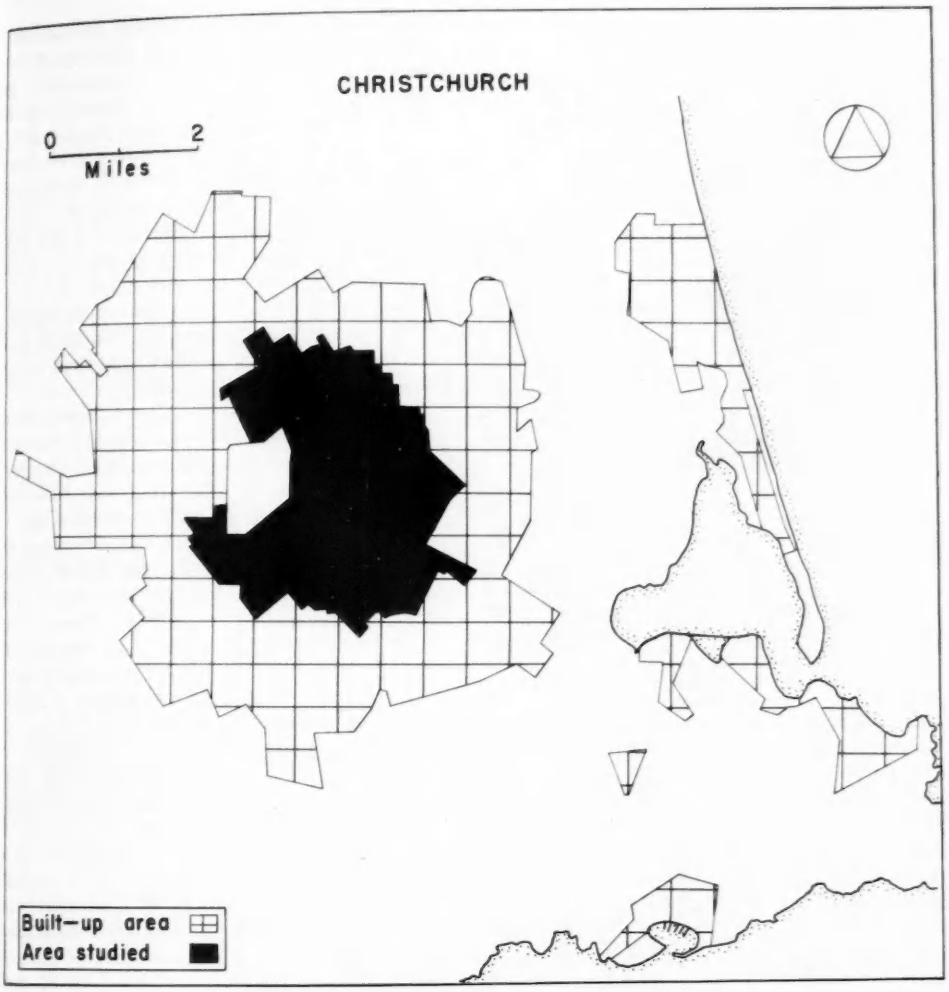


FIGURE 1

houses is based upon an analysis of the records of the Valuation Department of the New Zealand government. Under its empowering legislation the Valuation Department is required to make a revaluation of all rural and urban property throughout the Dominion every five years. A field record is kept in each district office for every urban property in its district. These records give not only the legal description, details of ownership and occupance, the acreage, and unimproved, improved, and capital values, but they also provide an estimate of the age of each house, a qualitative but very general assessment of its physical condition, and the square footage of the different parts of each house. This provides the most complete record relating to the age, area, and general physical condition of houses in New Zealand. None of these items is enumerated in the five-year census.

The present survey, made in 1955/56, was confined to the older residential districts of Inner Christchurch and Inner Dunedin. The limits of the areas surveyed were somewhat arbitrarily defined so as to include all of what was thought, or known, to be the continuously built-up portions of these two cities in 1891 (Figs. 1 and 2). At that date Christchurch

FIGURE 2

and Dunedin were of approximately similar size, having 48,000 and 46,000 inhabitants respectively within their administrative limits and suburbs. Because of their comparable size, approximately the same number of houses were included in the present survey of each city, although Christchurch today is approximately twice as large as its southern neighbor. For the present survey, 12,070 dwellings were included in the area defined for Christchurch (Fig. 3) and 11,031 for the comparable area in Dunedin (Fig. 4). They comprised 21.8 percent in Christchurch and 39.4 percent in Dunedin of the total number of houses in the urban areas.[4]

The value per square foot of living space was calculated for each house as at the time of the last complete revaluation in 1955/56.[5] This value was then expressed as a percentage of the standard replacement cost used by the government valuers in 1955/56; for example, in Christchurch the standard replacement cost was £2. 10. 0. (50/–) per square foot in 1955/56, and in Dunedin the standard varied from £2. 2. 6. (42/6), through £2. 5. 0. (45/–), to £2. 7. 6. (47/6), according to the base adopted for revaluing different residential districts. On this basis a house in Christchurch valued at 5/– (£0.25) or less per square foot (that is, one-tenth or less of its replacement cost) was considered to be depreciated by 90 percent or more of its replacement cost; a house valued between £0.26 and £0.50 per square foot was considered to be depreciated by 80–90 percent.

The houses in each street block were grouped into what were considered to be four significant categories: 90% and more depreciation; 80% and more depreciation; 70% and more depreciation, and 60% and more depreciation. These data were plotted on maps to give an over-all picture by street blocks of the number and general location of marginal and submarginal houses (Figs. 5–12). One of the more significant thresholds of depreciation distinguished here was that separating low-value housing from marginal houses. A house that was worth, say, only one-fifth of its replacement cost in 1955/56 is assuredly of low value (and of poor quality); this may perhaps also be said of a house that is depreciated by 72, 75, or 78 percent. It has seemed reasonable and convenient, however, to draw a somewhat arbitrary boundary at 80 percent to differentiate the houses of low value from the marginal houses. By this measure, houses depreciated by more than 80 percent were of low value, and those depreciated by 90 percent or more were of extremely poor quality, as a field check revealed.

The value of a house has been taken here as an expression not only of its physical condition but also of the degree of obsolescence of its design and fittings, and the general environment of the neighborhood in which it is located. All of these factors enter into an assessment of residential quality and find expression in the value placed on a property. The actual value arrived at by the government valuers in New Zealand is influenced by the prices paid in the open market for similar types of property in the same locality. By law the details of every sale of property are returned to the Valuation Department and these

[4] Department of Statistics, *Population Census (1956)*, Volume IX, *Dwellings and Households* (Wellington, 1959), p. 29.

[5] Outside sheds, separate laundries, external improvements (such as paths, fences, and trees), and the value of the land itself were excluded for this purpose.

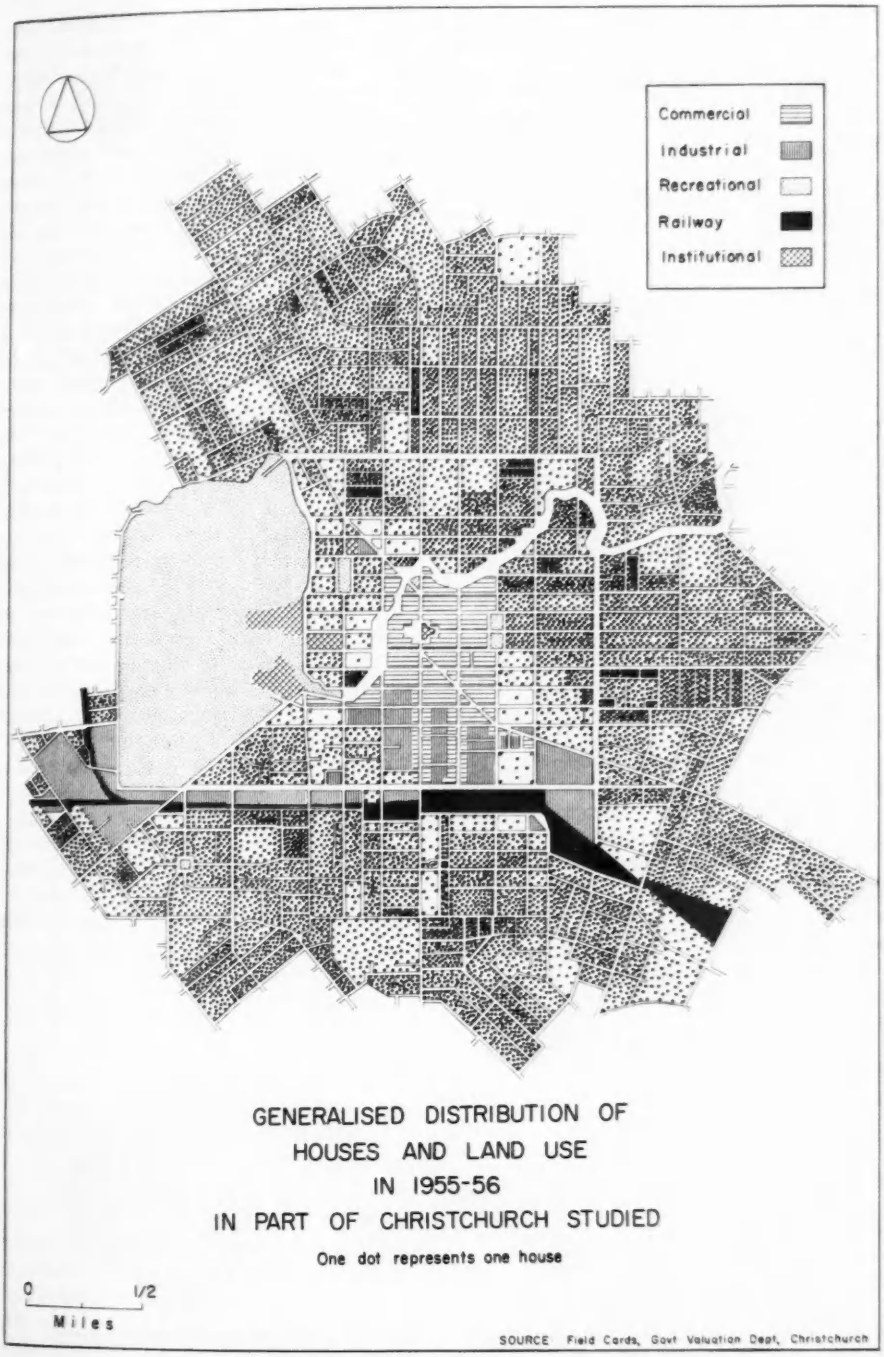

Commercial
Industrial
Recreational
Railway
Institutional
GENERALISED DISTRIBUTION OF
HOUSES AND LAND USE
IN 1955-56
IN PART OF CHRISTCHURCH STUDIED
One dot represents one house
0 1/2
Miles
SOURCE: Field Cards, Govt Valuation Dept, Christchurch

FIGURE 3

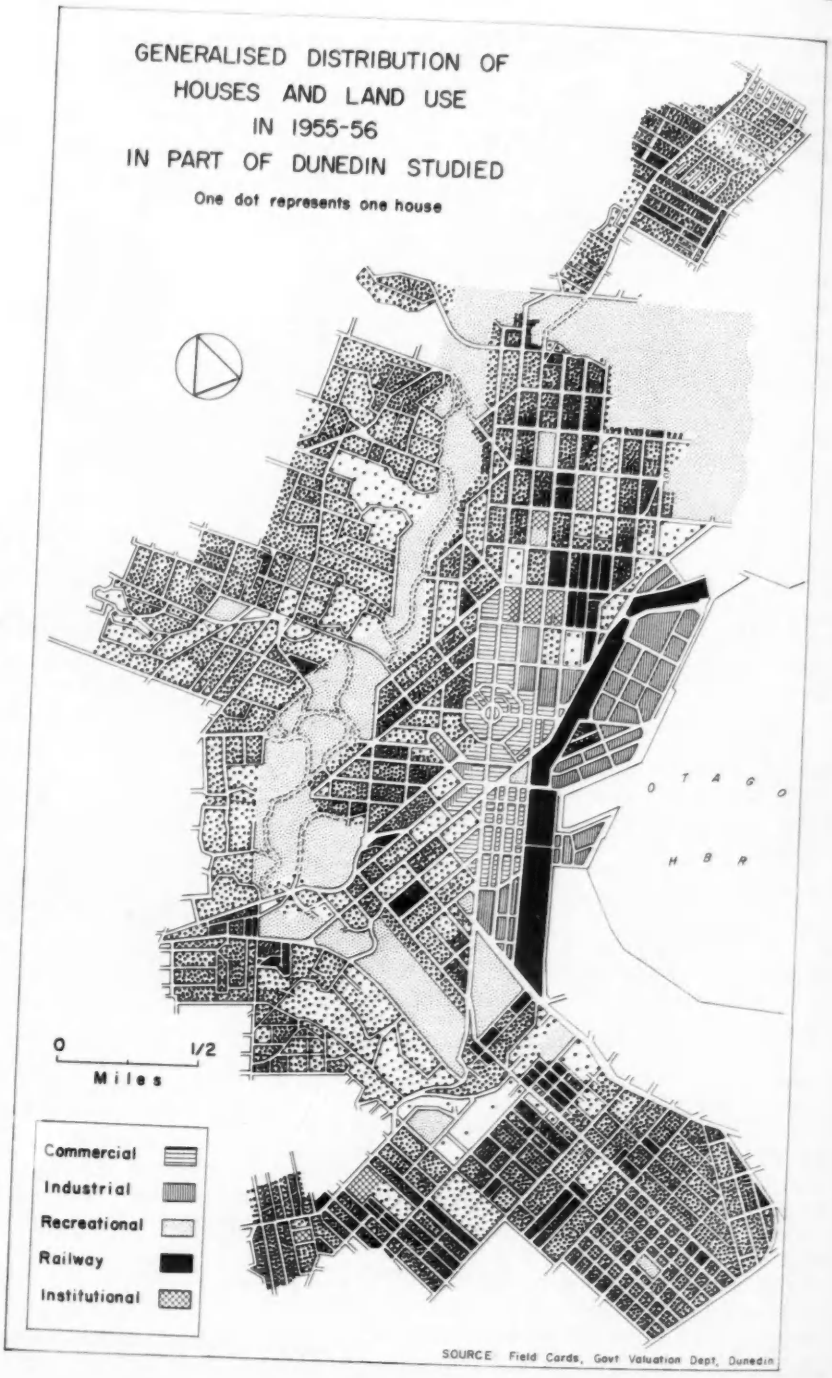

GENERALISED DISTRIBUTION OF
HOUSES AND LAND USE
IN 1955-56
IN PART OF DUNEDIN STUDIED
One dot represents one house
O T A G O
H B R
0 1/2
Miles
Commercial
Industrial
Recreational
Railway
Institutional
SOURCE Field Cards, Govt Valuation Dept, Dunedin

FIGURE 4

provide the necessary check on ruling market prices. Furthermore, by exercising their right of appeal to an impartial judge against the valuations placed on their properties, many owners provide another series of correlative checks among the values of similar types of property and also between ruling market prices and government valuation.

The greatest weakness in this method of using government valuations as a measure of housing quality occurs in districts of high land value close to the central business districts. The weakness arises from the empowering legislation in New Zealand which requires that the value of improvements be calculated by subtracting the value of the land from the capital value (that is, the total worth of the property). Where residential land around the central business district is highly sought for conversion to commercial or industrial use, the effect is to depreciate abnormally the value of the improvements. While this is a disadvantage of this method, as far as it has been developed here, the zones of influence are definitely restricted. It should be possible, given time, for government valuers to calculate from their records of sales the amount of distortion that has occurred in land and capital values in these zones. A simple, compensatory adjustment could then be made. This was not done in the present study. In its present form and without adjustment, the method of calculating depreciation from the present replacement costs seems to provide a ready and moderately satisfactory way of measuring residential quality in the larger cities of New Zealand. This may be demonstrated in the cases of Christchurch and Dunedin.

THE CONTEMPORARY SITUATION

Christchurch

Out of the 12,000 houses surveyed in Christchurch in 1955/56, no fewer than 13.6 percent were depreciated by 80 percent or more of their replacement cost (Table 1). Of this number 0.9 percent were depreciated by 90 percent or more. These might well be considered ready for demolition. Equally disquieting is the conclusion that an additional 33 percent of the houses in the inner districts of Christchurch were in the 70–80 percent depreciation category; they might be considered in, or approaching, a marginal condition.

TABLE 1.—PROPORTION OF HOUSES IN INNER CHRISTCHURCH IN VARIOUS DEPRECIATION CATEGORIES, 1955/56[1]

(Depreciation expressed as percentage of replacement cost per square foot in 1955/56)

Depreciation category	Percent	Number
90 percent and more	0.9	108
80–90 percent	12.7	1,527
70–80 percent	33.3	4,015
60–70 percent	20.7	2,497
Other	32.4	3,923
Total	100	12,070

[1] Source: Field cards, Government Valuation Department, Christchurch.

To most New Zealanders these would be rather startling figures, but they seem to be of the order that students of cities in North America might have expected in the circumstances. That these results would probably come as a surprise to the average citizen of Christchurch underlines his general unawareness about the poorer parts of the city outside of the neighborhood in which he may work and through which he is accustomed to travel. Even for these restricted neighborhoods with which he is familiar, his critical opinion has probably been dulled by his frequent but passing exposure to their landscapes. Most people do not appear to see the onset of decadence, decay, and general urban blight until the condition is so advanced as to require remedial treatment that is drastic and extremely expensive.

One of the reasons for this lack of awareness in Christchurch is that the houses of poorest quality are widely scattered throughout most of the older parts of the city; for this reason they tend to be not conspicuous (Fig. 5). The houses of 80 percent or more depreciation (which also includes those in the 90 percent category) are more concentrated in some districts than are the poorest houses, although individual houses of submarginal condition are to be found in most parts of the inner city (Fig. 6). The largest concentrations occur in three districts: south of the central industrial area and railway marshalling yards (see Fig. 3 for generalized land-use areas); east of the central commercial area; and north of the city center.

In both the southern and eastern areas there has been a considerable amount of infiltration by factories over the last 20 years among the

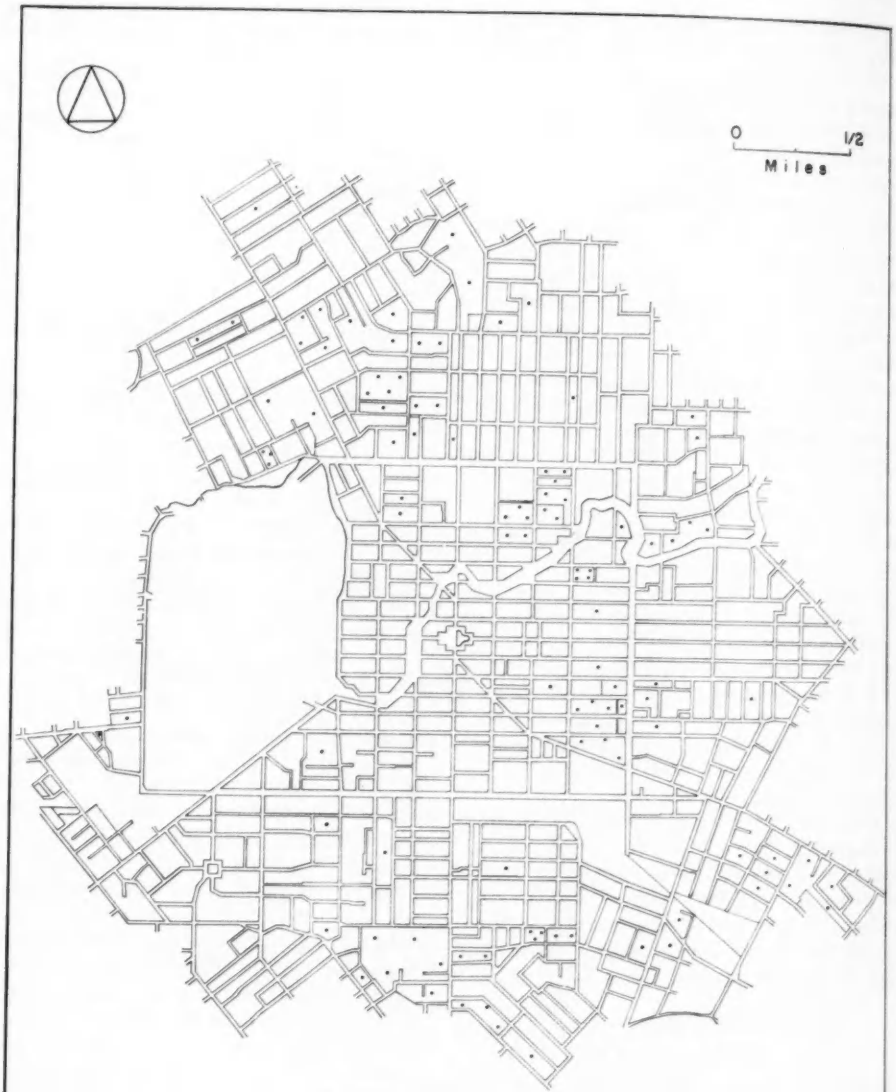

0 1/2
Miles
HOUSES DEPRECIATED BY
90% OR MORE OF REPLACEMENT COST
IN 1955-56
IN PART OF CHRISTCHURCH STUDIED
One dot represents one house
SOURCE: Field Cards, Govt Valuation Dept, Christchurch

FIGURE 5

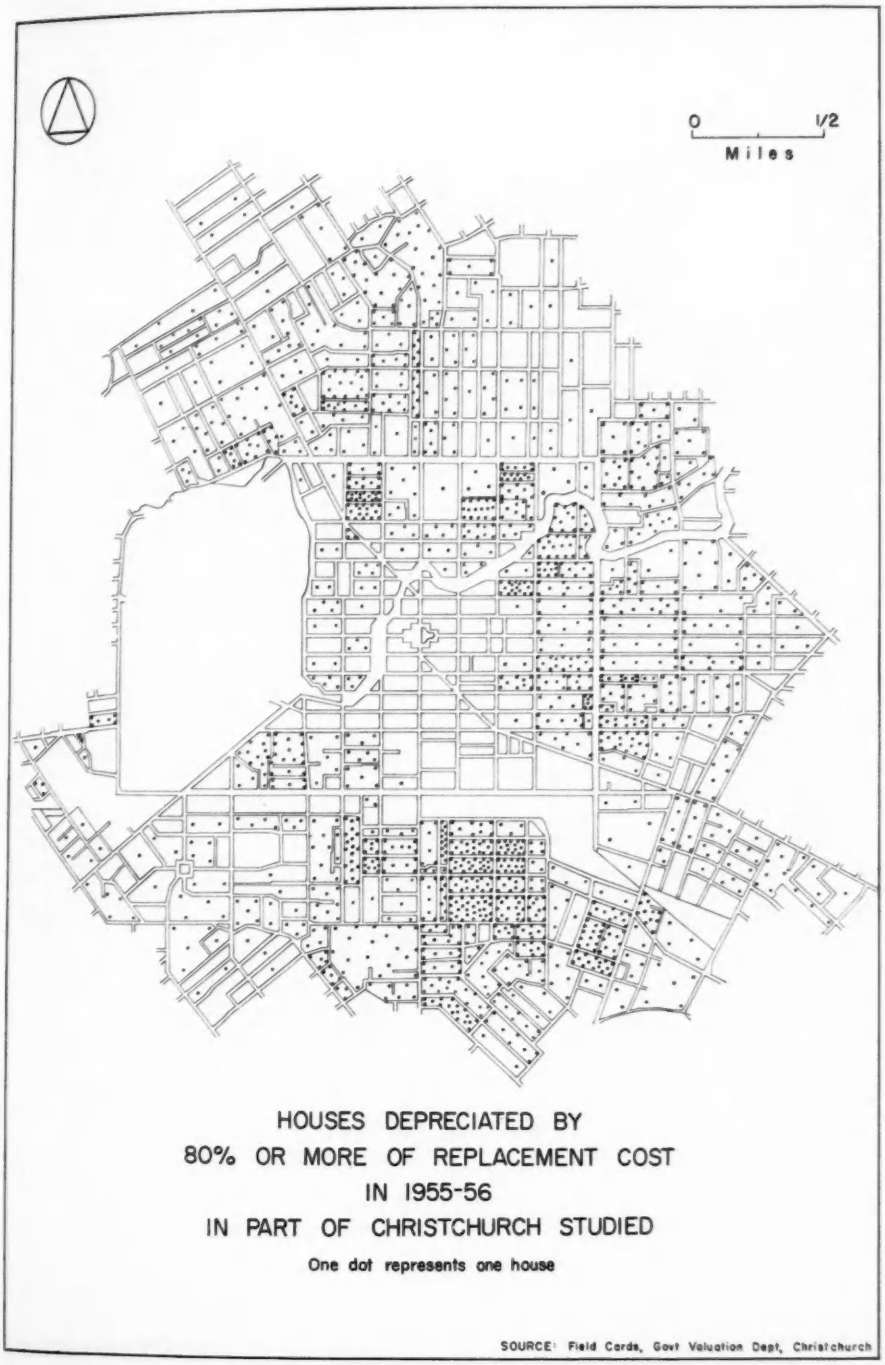

0 1/2
Miles
HOUSES DEPRECIATED BY
80% OR MORE OF REPLACEMENT COST
IN 1955-56
IN PART OF CHRISTCHURCH STUDIED
One dot represents one house
SOURCE: Field Cards, Govt Valuation Dept, Christchurch

FIGURE 6

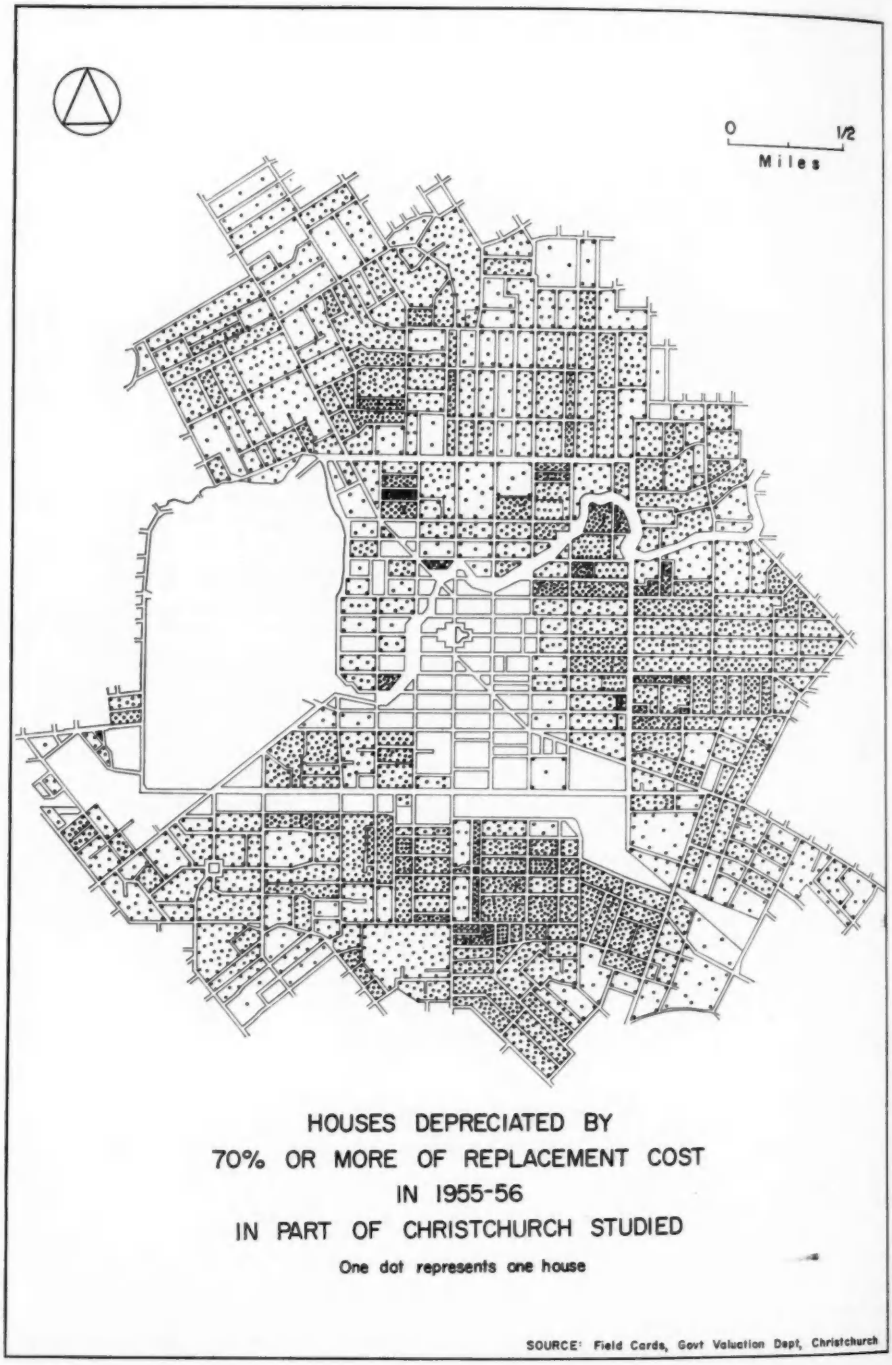

0 1/2
Miles
HOUSES DEPRECIATED BY
70% OR MORE OF REPLACEMENT COST
IN 1955-56
IN PART OF CHRISTCHURCH STUDIED
One dot represents one house
SOURCE: Field Cards, Govt Valuation Dept, Christchurch

FIGURE 7

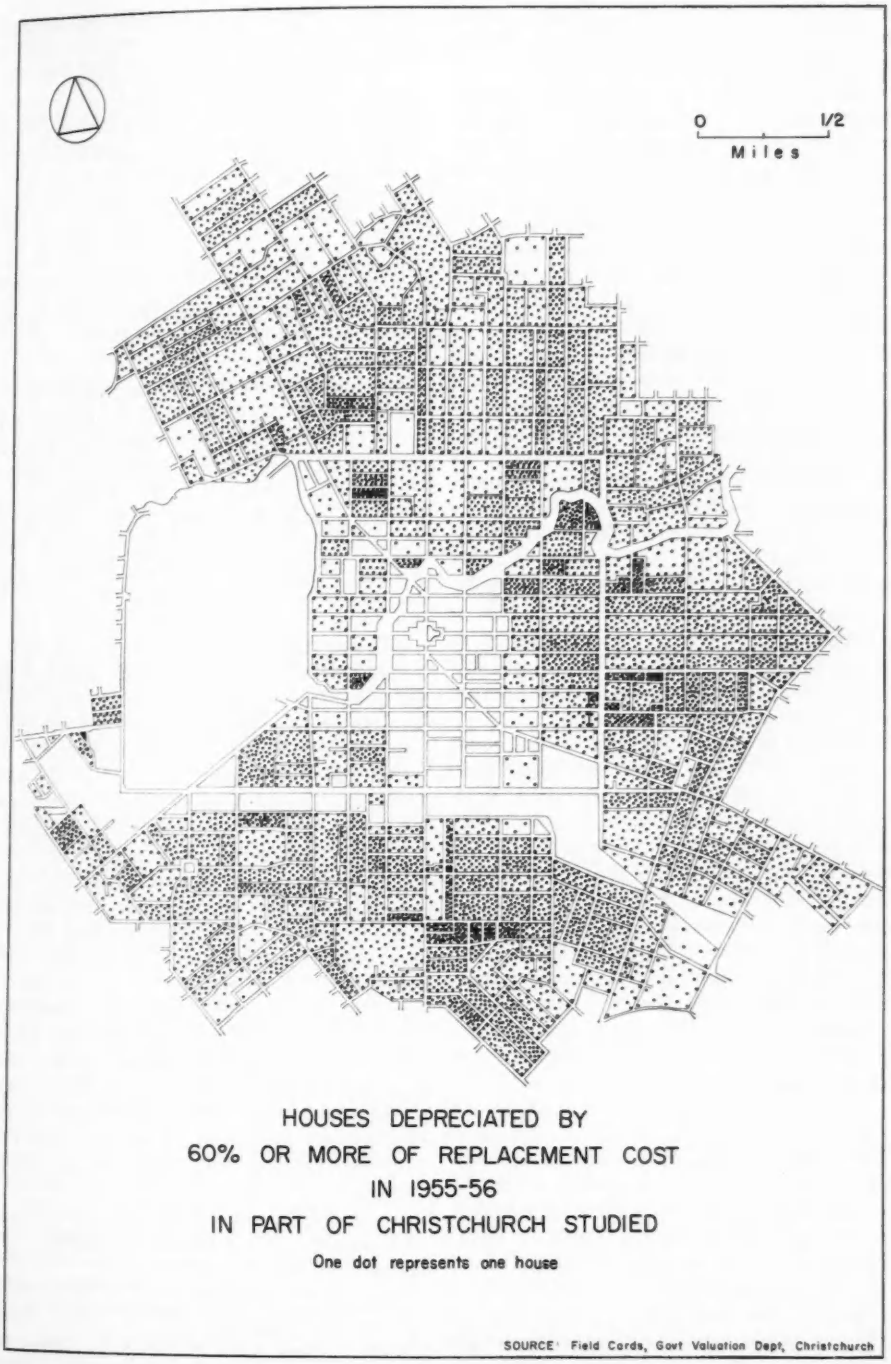

0 1/2
Miles
HOUSES DEPRECIATED BY
60% OR MORE OF REPLACEMENT COST
IN 1955-56
IN PART OF CHRISTCHURCH STUDIED
One dot represents one house
SOURCE: Field Cards, Govt Valuation Dept, Christchurch

FIGURE 8

cottages and villas, which helps explain the lower quality of the homes. Another factor in the eastern and northern areas is that many of the houses there were built at an abnormally high density for New Zealand; for example, in contrast to the customary suburban density of 5 to 7 houses per acre, several of the lots in these two areas measure approximately one-twentieth of an acre. The cottages today on these small plots are small, old, obsolescent, and often in poor physical condition. The invasion by factories and small warehouses, where it has occurred, has produced a malaise among the house owners towards building maintenance. This has been coupled with an inability to find money for maintenance, where land values have risen disproportionately, because of the increased tax load produced by industry and commerce.

In the area of poorer houses immediately north of the city center a further contributing factor has been the peaty soil in some pockets of land. Where this occurs the piles have often sagged, the doors and windows have jammed, and the walls, floors, and verandas have buckled. The presence of houses affected in this way has often had a detrimental effect on their immediate neighbors.

Houses in Inner Christchurch that were depreciated by 70 percent or more in 1955/56 are found in almost every residential block (Fig. 7). There are marked concentrations in some blocks within the main problem areas discussed above. The general location of these marginal blocks becomes even more apparent on the map of houses depreciated by 60 percent and more (Fig. 8). These would seem to be the major problem areas in Christchurch, and the areas where the first detailed field surveys should be made by the responsible authorities when preventive or remedial action is taken.

Dunedin

The survey of Inner Dunedin shows several interesting contrasts in the residential structure by comparison with Christchurch. Whereas 13.6 percent of the houses surveyed in Inner Christchurch were depreciated by 80 percent or more, only 4.8 percent were comparably depreciated in Dunedin (Table 2). The disparity was far less marked in the case of houses depreciated by 90 percent or more with 0.9 percent in this category in Christchurch and 0.5 percent in Dunedin. In the marginal category of 70–80 percent, however, Dunedin showed up far more favorably than did Christchurch with only 12.8 percent while Christchurch had 33.3 percent.

TABLE 2.—PROPORTION OF HOUSES IN INNER DUNEDIN IN VARIOUS DEPRECIATION CATEGORIES, 1955/56[1] (Depreciation expressed as percentage of replacement cost per square foot in 1955–56)

Depreciation category	Percent	Number
90 percent and more	0.5	62
80–90 percent	4.3	475
70–80 percent	12.8	1,409
60–70 percent	23.4	2,579
Other	59.0	6,506
Total	100	11,031

[1] Source: Field cards, Government Valuation Department, Dunedin.

There are several reasons why the quality of older houses in Inner Dunedin is often higher than in Christchurch. First, a much larger proportion of the older houses in Dunedin were built of brick or concrete and had plastered interior walls. The rate of depreciation has been lower on these buildings than on the houses of wood frame, weatherboard, and interior wood lining construction. Second, unlike Christchurch, which has a relatively limitless amount of flat land stretching 20 miles to the north, 40 miles to the west, and 100 miles to the south,[6] the urban area of Dunedin largely occupies land of undulating to steep slope.[7] Most of this flat land lies to the east of the main north–south axis that bisects the central commercial area (Fig. 4), and includes the whole district lying to the south and southeast of the central industrial area. All of this flat land was occupied by 1901.[8] Since that date there has been a ready demand by elderly people of modest means for any cottages and villas that have become available on the flat. This ready demand has helped support the values of some property in Dunedin that would be considerably

[6] See F. Parks, "Land Utilisation in Metropolitan Christchurch," *New Zealand Geographer*, Vol. 2 (1946), pp. 279–80.

[7] See A. D. Tweedie, "Land Utilisation in Metropolitan Dunedin," *New Zealand Geographer*, Vol. 8 (1952), pp. 30 and 32.

[8] W. T. Neill, *Field Sheets of the Military Topographical Plan, Dunedin and Suburbs* (Dunedin, 1901).

cheaper—and of poorer quality—if they were in Christchurch. Higher house values have made it well worth while for many property owners in the flatter parts of older Dunedin to keep their houses in good condition. Third, there has been much less spread of factories and commercial businesses into the older districts of Dunedin, partly because the economic growth of that city has not matched that of Christchurch, which is the fastest-growing large industrial center in the South Island; and fourth, there are no significant pockets of peaty soil in Dunedin that would cause houses built on them to settle. For these reasons many of the older houses in Dunedin are of higher quality today than houses of comparable age in Christchurch.

A further significant contrast between these two cities lies in the pattern of distribution of the various depreciation categories. Almost all of the poorest housing in the older part of Dunedin in 1955/56 lay immediately to the northwest and away to the north from the central commercial area (compare Figs. 4 and 9). It was, therefore, much more concentrated than comparable housing in Christchurch. In these two areas, as well as elsewhere in older Dunedin, many individual house lots measure as little as one-thirty-second of an acre. On these are minute wooden cottages, many of which have now reached the limit of useful life. Contributing to their depreciation in many cases has been the proximity of the central commercial area (and the expectation of an ultimate change in use), and the actual overspill of business to the north from the central business district. For the houses more distant from the city center, however, low quality and decadent condition are primarily a result of age; 90 or 100 years or more have passed since they were built.

In contrast to the relative concentration of the poorest houses, those depreciated by 80 percent or more were as widely scattered as houses of similar quality in Christchurch (compare Figs. 10 and 6). At the same time, the bulk of them were located within the limits of the original town as it was first laid out, these limits being clearly shown on Figure 4 by the "town belt" of recreation land, which occupies land of generally steep slope.[9] A large number of these poor houses are small, detached, single-story cottages built on microscopic pieces of land that were originally subdivided as tent sites. One of the earliest cottages (not in this particular category) actually occupies a lot measuring only 8,000 square feet. Sections of 16,000 square feet are quite common within the original town belt of Dunedin and are in far greater numbers than in Christchurch. The primary reason for the poor quality of many of the small, wooden cottages to the west of the urban axis of Dunedin is their advanced age, together with an insufficient amount of maintenance to offset natural decay. Not as much money has been spent on many of these properties as elsewhere within the town belt because the land on the western side is of undulating or sometimes steep slope; hence there has been less demand for the cottages here. On the flat land to the east and south of the main urban axis the poor conditions reflect proximity to factories and marshalling yards, initial defective and substandard construction, inadequate maintenance (often associated with rented property), and inevitable obsolescence and decay among old wooden houses that have been built over many blocks at the abnormally high density of 7,000 to 24,000 square feet of land per dwelling.

In Dunedin even more markedly than in Christchurch, the houses in the category of 70 percent and more depreciation are widely and thickly distributed within the limits of the original town (Fig. 11). Striking concentrations occur in two places: on markedly sloping land in the southwestern corner of the original town where sites for tents were subdivided; and in the northeast where old brick row-houses, which lack direct access for motor vehicles, recreate in contemporary New Zealand the 19th century townscapes of Industrial Britain.

Houses in the 60 percent or more category of depreciation (Fig. 12) show a disproportionate concentration on the flat land to the northeast of the central commercial area (where the expansion by businesses has been most marked in the past and is most likely in the future), and in the tent site quarter to the southwest. The more youthful properties on the upper surfaces to the west of the town belt and in the extreme southeast of the area studied have an expectably lower incidence

[9] See also the relevant maps and discussion in Tweedie, *op. cit.*

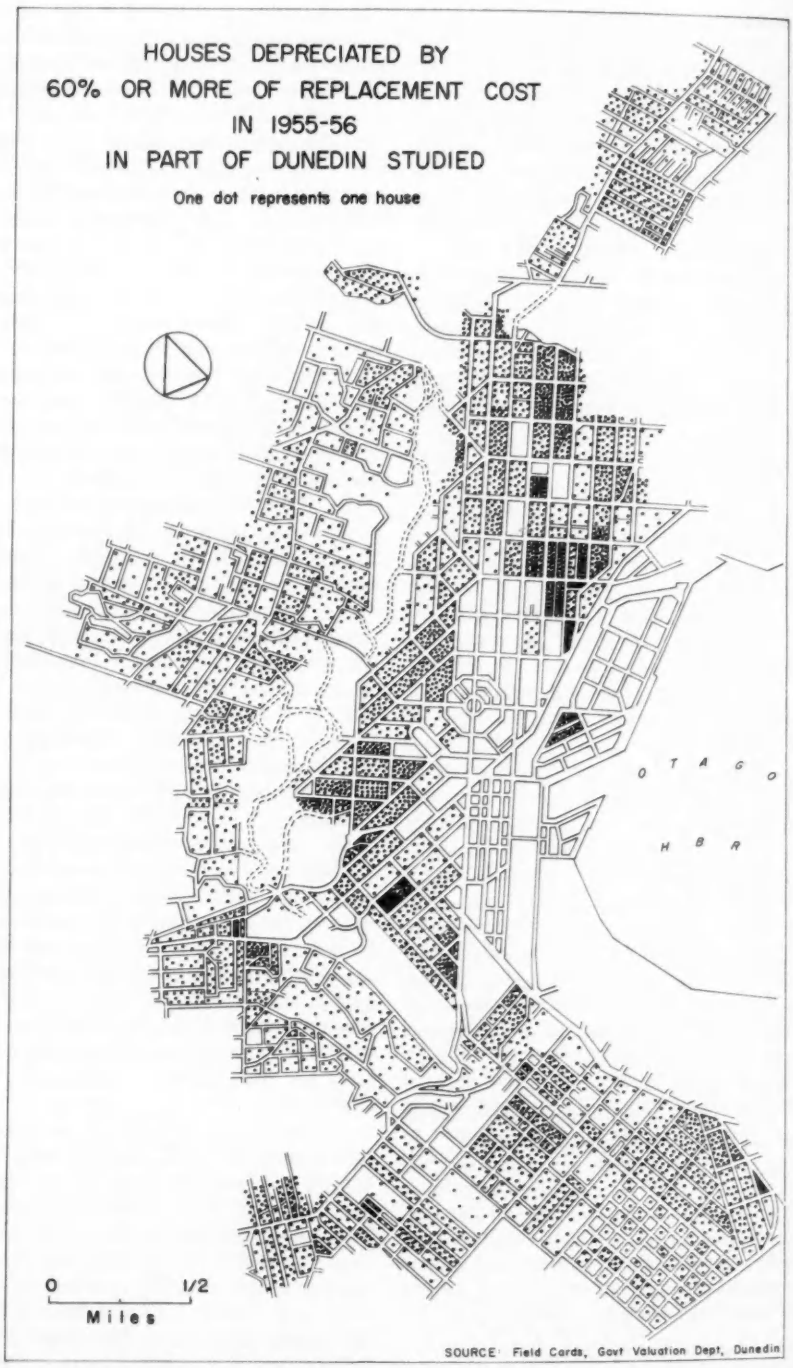

HOUSES DEPRECIATED BY
60% OR MORE OF REPLACEMENT COST
IN 1955-56
IN PART OF DUNEDIN STUDIED
One dot represents one house
O T A G O
H B R
0 1/2
Miles
SOURCE: Field Cards, Govt Valuation Dept, Dunedin

FIGURE 9

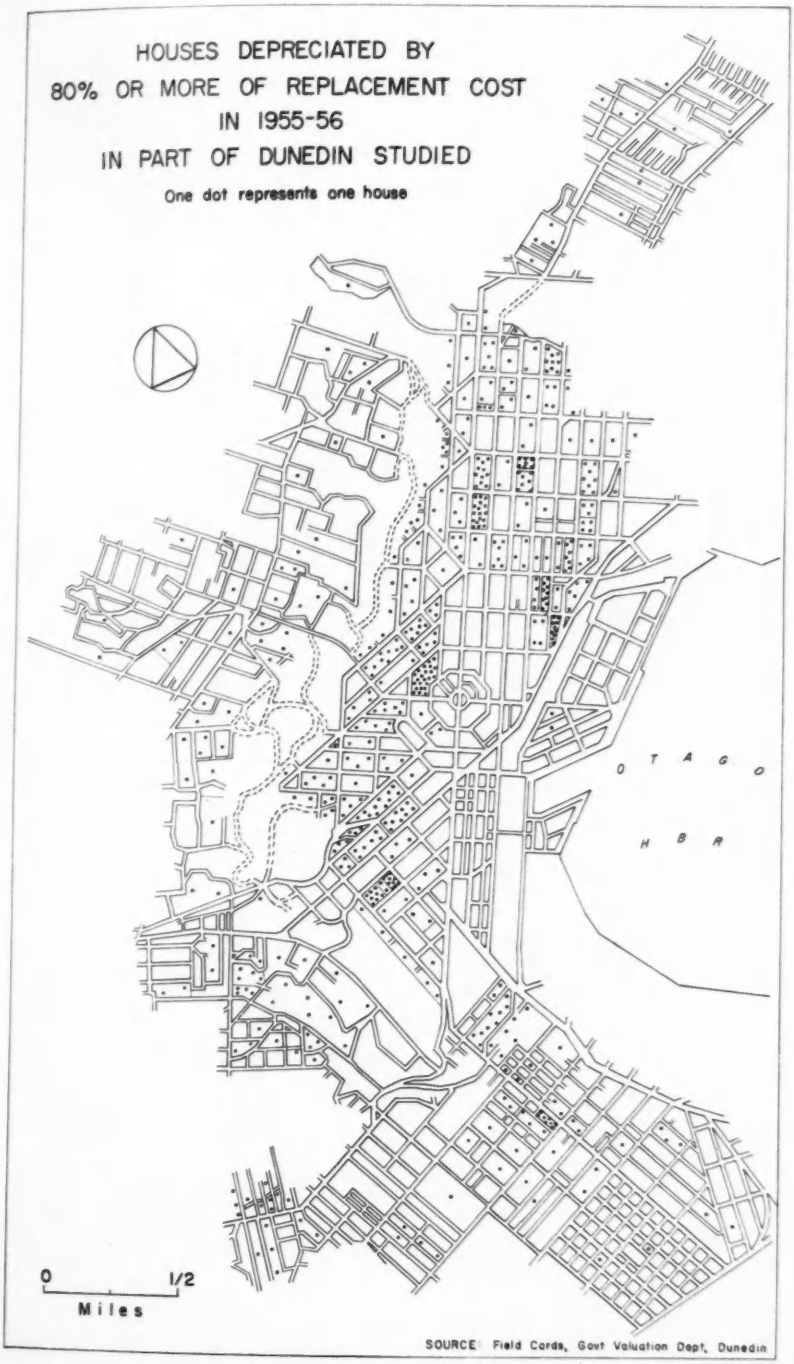
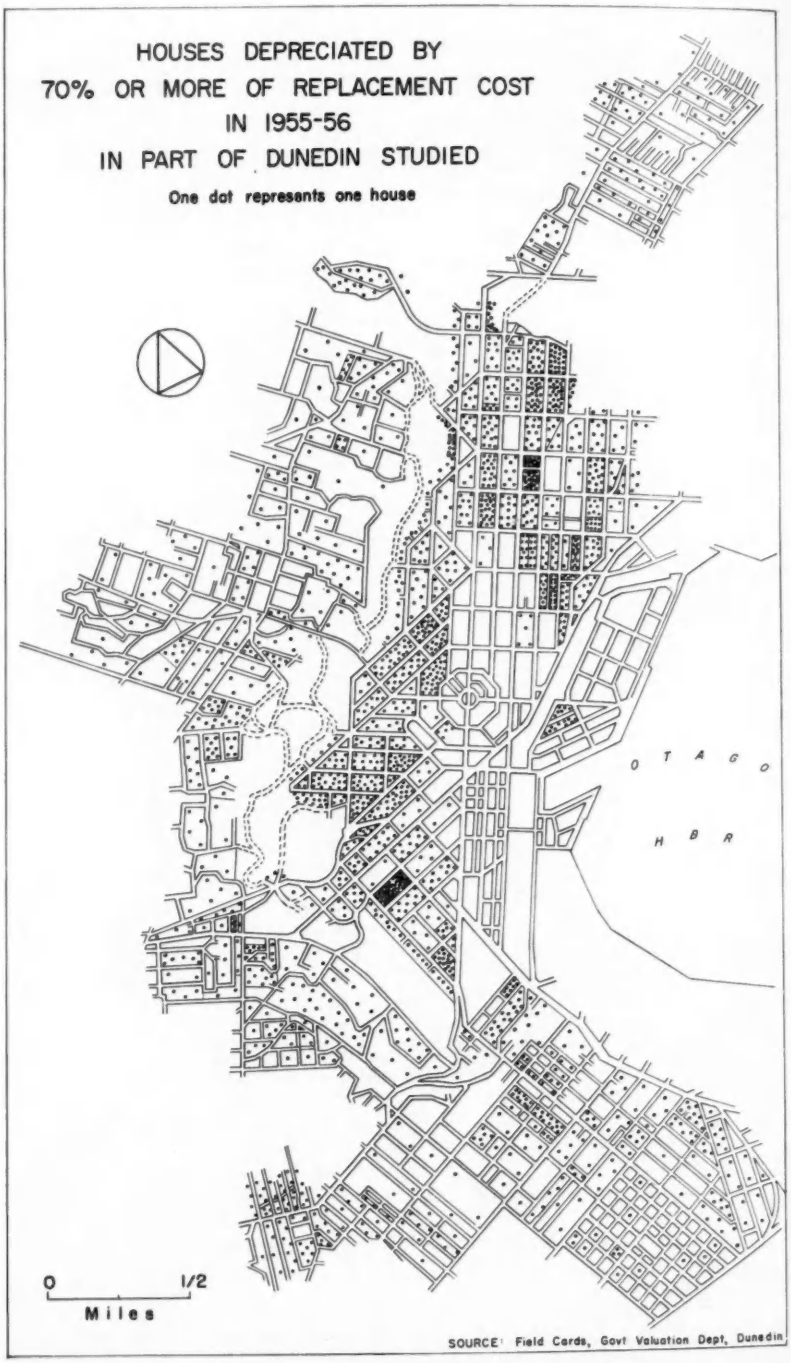

HOUSES DEPRECIATED BY
80% OR MORE OF REPLACEMENT COST
IN 1955-56
IN PART OF DUNEDIN STUDIED
One dot represents one house
O T A G O
H B R
0
1/2
Miles
SOURCE: Field Cards, Govt Valuation Dept, Dunedin

FIGURE 10


HOUSES DEPRECIATED BY
70% OR MORE OF REPLACEMENT COST
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IN PART OF DUNEDIN STUDIED
One dot represents one house
O T A G O
H B R
0 1/2
Miles
SOURCE: Field Cards, Govt Valuation Dept, Dunedin

FIGURE 11

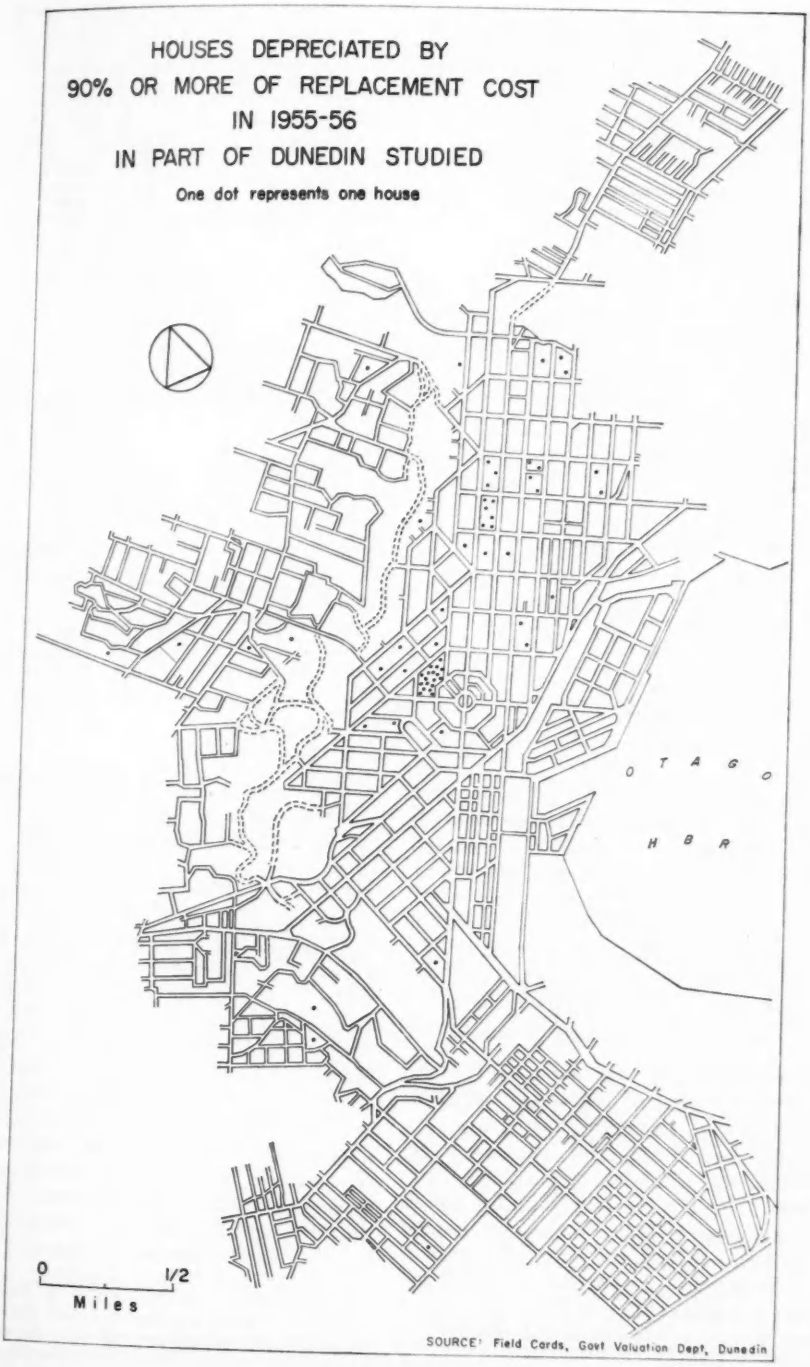
HOUSES DEPRECIATED BY
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FIGURE 12

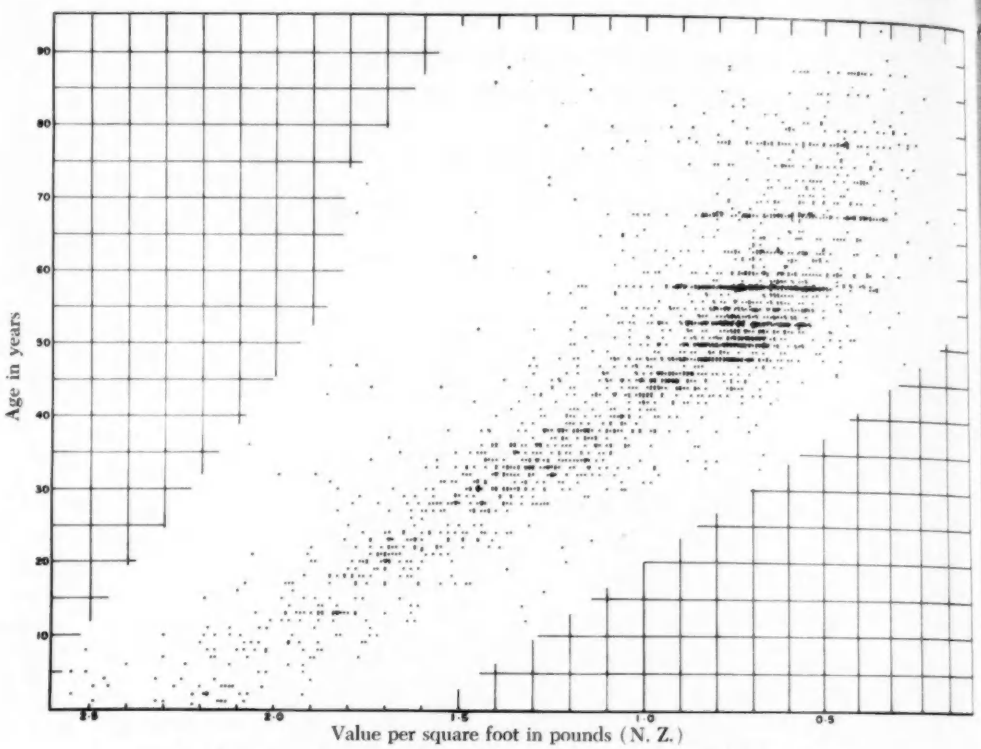

FIG. 13. Age and value of houses in part of Christchurch studied, 1955/56.

of poorer quality houses. In a comparative sense, however, the houses of 60 percent or more depreciation are even more concentrated in Dunedin than in Christchurch. If a time comes when housing reclamation is undertaken in Dunedin, whole districts of the inner city may probably need tackling concurrently instead of only single isolated blocks at a time, as will probably be the case in Christchurch.

PROGNOSTICATION

What changes may be expected in the future in the number of low-value houses in Christchurch and Dunedin? An answer to this question can be found by using the housing situation in 1955/56 as a basis for prognostication. (This is the only date for which data are available relating to the age, surface area, and value of houses). In any forecast of this type it must be assumed that all of the conditions bearing on housing quality remain the same in future years as in the past.

In order to estimate the future numbers of low-value houses, random samples of approximately one house in five of those studied were plotted according to the age and value per square foot of living space (Figs. 13 and 14).[10] These samples were then grouped for statistical analysis into several broad categories according to their ages and categories of depreciation. Five-year periods were selected for convenience, and attention was confined to the three critical categories of depreciation: 90 percent and more, 80–90 percent, and 70–80 percent. The number of samples in each age and depreciation category was converted to the actual number of houses; for example, in the group of 85–89-year-old houses in Christchurch there were two samples (or 11 houses, when the sample was multiplied by the sampling factor of 5.44) in the 90 percent category, 16 samples (87 houses) in the 80 percent category, and six

[10] I am grateful to Professor H. P. Bailey for his interest and helpful suggestions and particularly for suggesting that graphical representation might help throw light on the problem of estimating the future incidence of low-value housing.

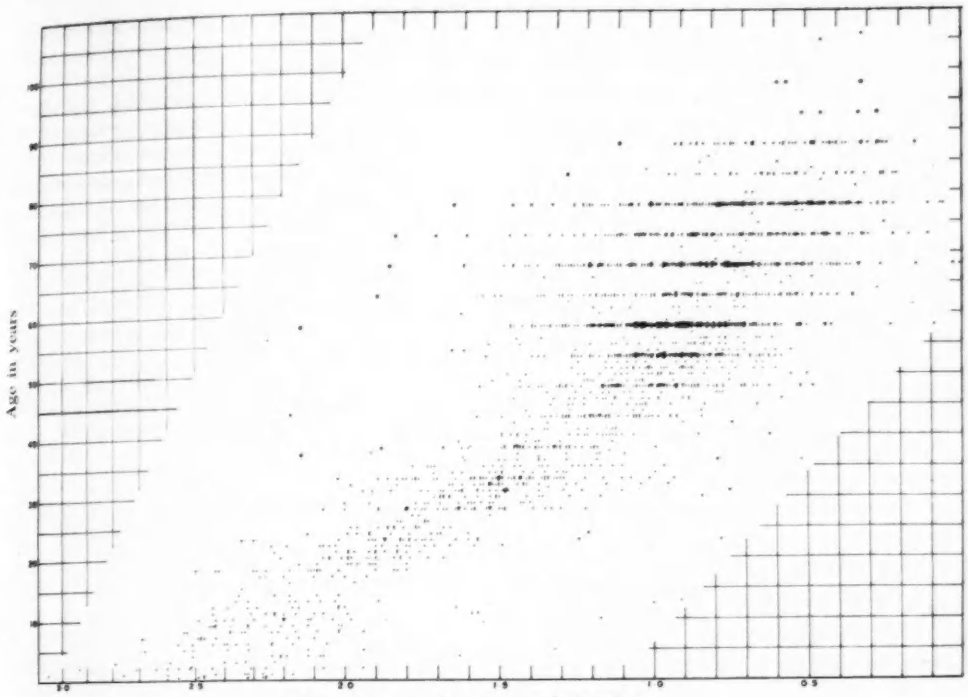

FIG. 14. Age and value of houses in part of Dunedin studied, 1955/56.

samples (33 houses) in the 70 percent category, out of a total of twenty-nine samples (157 houses). Of the houses from 85 to 89 years old in 1955/56 approximately 7 percent fell in the 90 percent depreciation category, 56 percent in the 80 percent depreciation category, and 21 percent in the 70 percent depreciation category. The structure of each five-year age group was calculated in the same way, those for the three oldest groups in Christchurch being shown, by way of further explanation, in Table 3.[11] The full table of age and depreciation categories for 1955/56 provided the basis on which the estimates of future numbers were made. A further example may make the method a little clearer.

In 1960/61, for example, the 201 houses that were 80–84 years old in 1955/56 will be in the 85–89 age group. On some of them little or no maintenance will have been car-

[11] Appreciation is expressed to Professor W. R. Andress and to Dr. R. M. Williams for their critical comments on this method of statistical projection.

TABLE 3.—PROPORTION OF HOUSES IN CRITICAL DEPRECIATION CATEGORIES, BY AGE GROUPS OF HOUSES 75 YEARS AND OLDER, IN INNER CHRISTCHURCH, 1955/56[1]

Age group of houses and item compared	Depreciation— 90 percent and more	80–90 percent	70–80 percent	Total in age group
90–94 years				
Number of samples		2		2
Number of houses		11		11
Percent of all categories		100		100
85–89 years				
Number of samples	2	16	6	29
Number of houses	11	87	33	157
Percent of all categories	7	56	21	100
80–84 years				
Number of samples	1	13	15	37
Number of houses	5	71	82	201
Percent of all categories	3	35	40	100
75–79 years				
Number of samples	4	35	41	97
Number of houses	22	190	223	528
Percent of all categories	4	36	43	100

[1] Source: Field cards, Government Valuation Department, Christchurch.

ried out during the intervening years and they may qualify for a lower category of value (that is, a higher depreciation category) than the one they were in five years earlier. Other houses will have been improved in quality, if past trends continue. On this assumption, the 201 houses from the 80–84 age group of 1955/56 were redistributed for 1960–61 according to the percentage composition of the 85–89-year group as we know it for 1955/56, namely 14 houses in the 85–89-year group in 1960/61 would be in the 90 percent or higher depreciation category, 112 would be in the 80–90 percent category, and 42 would be in the 70–80 percent category.

It will be seen from Figure 13 that no house older than 94 years appeared in the sample taken. Because nothing is known about houses of greater age, it has been supposed here (for the moment) that their quality will remain static, neither appreciating nor depreciating further after the age of 94 years has been reached. It is with these working principles that a "crude" estimate of critical depreciation categories for Christchurch from 1955/56 to 1985/86 has been devised.

This crude estimate suggests that by 1960/61 more than 2,000 houses in Inner Christchurch may be in the low-value category of 80 percent or more depreciation. Fifteen years later the total in the same category may reach 4,100, and by 1985/86 it may include 5,900 of the 12,070 houses surveyed. From the crude total of low-value houses at each projection period, however, must be subtracted the number of low-value dwellings that are likely to have been demolished or converted to other uses in Inner Christchurch.

The only records that have been kept relating to demolitions in metropolitan Christchurch are the cancelled entries in the registers of the Christchurch Drainage Board, the authority responsible for all sewer installations. An examination of the detailed entries covering the first 40 years of public drainage service in Christchurch from 1880 to 1920 shows that 155 cancellations were made from all types of buildings during the three years 1955–1958, that is, an average of 51 disconnections per year.[12] Unfortunately, in these registers there is no way of differentiating houses from other types of buildings; quite evidently not more, and probably fewer, than 51 houses a year were demolished. Not all of the houses demolished, however, where they could be traced, were in poor condition. Only 54.2 percent of those traced were depreciated by 80 percent or more, and only 1.7 percent were depreciated by 90 percent or more. This difference suggests that on the average not 51 but only 27 houses of poor quality were demolished each year in the inner part of Christchurch covered by the present survey. This number of demolitions would not seem to reduce very significantly the totals set out in the preceding paragraph. To their number, however, must be added the low-value houses converted to other uses.

An examination of the relevant data[13] shows that 28 permits were issued during these three years covering house properties within the area surveyed in this paper. These houses could have been either converted to industrial use, or demolished for replacement by factories. Several were demolished and have been included in the data already considered. Another 30 houses may possibly have been converted for commercial use, although there are no extant data on this aspect. It is reasonable to assume that most of these converted houses would have been of reasonable quality. Altogether, say, 60 houses in all types of condition were converted between 1951 and 1958, or 20 conversions from residential use were made each year. Probably no more than half of these were substandard houses.

For the purpose of estimating the future incidence of low-value houses in Inner Christchurch, therefore, one might take as a crude basis 27 demolitions and 10 conversion for an average year between 1955 and 1985. It may be argued, however, that only a relatively few poor-quality houses have been demolished or converted in the past because only a small number of houses were in this condition. According to this argument, as a greater number of houses enter the low-value category in the future, so the number of demolitions and

[12] Christchurch Drainage Board, "Register of Connections with Sewers, Volumes 1–4," unpublished, 1880–1920.

[13] Christchurch Regional Planning Authority, "Distribution Map of Building Permits of Industrial Buildings Issued for the Christchurch Planning Region," unpublished, 1956–58, and "Map of Land Use for the Christchurch Planning Region," unpublished, 1955–56.

TABLE 4.—ESTIMATED NUMBER OF LOW-VALUE HOUSES IN INNER CHRISTCHURCH 1960/61 TO 1985/86

	1960/61	1965/66	1970/71	1975/76	1980/81	1985/86
Projected number	2,060	2,500	3,890	4,180	4,940	5,920
Estimated demolitions and conversions	199	431	723	1,108	1,527	2,021
Estimated number of low-value houses	1,860	2,070	3,170	3,070	3,410	3,900

conversions will increase. This point of view also merits brief examination.

From Table 1 it can readily be seen that in 1955/56 there were 1,635 houses that were depreciated by 80 percent or more. The assumption that 27 of the 1,635 houses in the low-value category were demolished in 1955/56 gives a ratio of 1 demolition to approximately every 60 low-value houses. If an increasing rate but a constant proportion of 1 to 60 is maintained from 1955/56 to 1985/86, approximately 1,730 low-value houses will have been demolished by the end of the period.

The argument developed above (of an increasing rate but constant proportion of demolitions) may well have produced an exaggerated rate of demolitions. In reality many more poor-quality houses may accumulate. Moreover, the same argument as to rate and proportion does not appear to hold true for conversions to other uses in future years. A relatively small number of low-value houses have been taken over in the past in Inner Christchurch for commercial use and there is no reason to expect that the present trend will be changed appreciably. It may well happen that little significant change will occur in the future in the rate at which low-value houses will be converted to factories in central Christchurch because of the scattered distribution of many of these houses, and because of the increasing tendency for factories to be located away from the city center.

For these reasons, the rate of future conversions in Christchurch may well be estimated at no more than 10 houses per year. Thus, by 1960/61, 1,860 houses of the 12,000 units surveyed may well be of low value; by 1970 they may total 3,170, probably rising by 1985/86 to 3,900 houses, or nearly one-third of all of the houses surveyed (Table 4).

The future outlook for Dunedin is almost as distressing. An analysis of the position (using a sample of 1 in every 4.95 houses in Inner Dunedin) suggests that while central Dunedin at present has a much smaller proportion of low-value houses than Christchurch, by 1985/86 the proportions will be much more similar, 39 percent in Dunedin, and 49 percent in Christchurch. The situation, however, changes considerably when possible conversion and demolition rates in the future are taken into account.

For the period 1956 to 1958, 118 demolitions were authorized by the Dunedin city council for the area under survey.[14] Of this number a sample survey shows one-half of the demolished houses (54.2 percent in Christchurch) were depreciated by 80 percent or more in 1955/56, and 14.3 percent (1.7 percent in Christchurch) by 90 percent or more. Assuming, as before, that an increasing rate but a constant proportion of 1 demolition to every 27 low-value houses (1:60 in Christchurch) is maintained down to 1985/86, a total of 2,400 poor-quality houses may possibly have been accounted for at that date by demolitions.

It is difficult to obtain a measure of the number of conversions of low-value houses that are likely to occur in Dunedin over the same period.[15] However, if the same number of 10 conversions per year of poor-quality houses is used for Dunedin as for Christchurch, the loss through demolitions and con-

[14] These totals were derived from an examination of individual permits for "taking down old buildings" issued by the Corporation of the City of Dunedin between January 1, 1956, and December 31, 1958.

[15] An examination of the "Building Register of the Corporation of the City of Dunedin" from January 1, 1953, to December 31, 1958, gives the improbable figure of 3 dwellings converted to other uses. A similar examination of the "Building Register of the City of Christchurch" from January 1, 1954, to December 31, 1958, showed only 5 similar conversions in Inner Christchurch, whereas other sources (cited earlier in the text) show that several more conversions took place.

TABLE 5.—ESTIMATED NUMBER OF LOW-VALUE HOUSES IN INNER DUNEDIN, 1960/61 TO 1985/86

	1960/61	1965/66	1970/71	1975/76	1980/81	1985/86
Projected number	1,074	1,385	2,165	2,477	3,604	4,805
Estimated demolitions and conversions	197	467	842	1,313	1,916	2,698
Estimated number of low-value houses	880	920	1,320	1,160	1,690	2,110

versions by 1985/86 will possibly total 2,700 (Table 5). This is likely to leave 2,100 (3,900 in Christchurch) poor houses, or approximately 19 percent (32 percent in Christchurch) of the 11,000 houses surveyed.

CONCLUSION

There is little doubt that no metropolitan community in New Zealand is alive to the fact that large numbers of low-value (poor-quality) houses are already to be found within its older residential districts. Even at the highest levels of local and national government there appears to have been a general lack of awareness of the magnitude of the problem that the metropolitan cities will have to face in the near future, because of the increase in slum housing. At present the metropolitan communities stand unprepared for the struggle against slums that lies ahead. Very few New Zealanders appreciate the great economic and social costs that the United States, Canada, and now Australia are at present paying for their unpreparedness in the past. Perhaps the lesson may still have to be learned in New Zealand, as it was in most other countries, by bitter experience.

The survey of the two metropolitan cities of the South Island of New Zealand at least suggests rather clearly that the time is probably not very far distant, if present attitudes and legislation remain unchanged, when houses of poor quality will exist in their older residential districts in such large numbers that no resident will be able to avoid seeing them, or to escape the unpleasant social and economic consequences of their existence. By that time it may be too late for either of these communities to completely solve the problem.

THE OIL AND GAS INDUSTRIES IN THE U.S.S.R.

PAUL E. LYDOLPH AND THEODORE SHABAD
University of Wisconsin, Milwaukee, and NEW YORK TIMES

DURING the period 1953–57 Soviet economists and other government personnel evaluated the broad features of the economy of their country in the light of expediencies and competitive costs and came up with some policy measures calculated to revamp certain sectors of the economy that were acting as bottlenecks to further development. These policies largely are embodied in the goals and procedures of the seven-year plan for 1959–65 and as such have been widely publicized in newspapers, magazines, and handbooks. Such publications, together with an unprecedented release of production statistics since 1956, afford a bench mark in time from which one can view the Soviet economy both backward and forward and discern significant trends now in progress that are destined to shape the character of the economy in years to come. It is quite possible now to identify some of the outstanding aspects that are planned for the future economic structure.

One of the most significant changes now taking place, that could not have been discerned from maps and statistics published even as late as 1956, is the change in the types of fuel consumption in the country. Whereas in 1940 coal accounted for more than 70 percent of all mineral fuel consumption and oil and gas accounted for only 24 percent, in 1972 coal is to account for only about 30 percent and oil and gas are to account for more than 60 percent. That this is a true reversal in policy can be seen by the fact that in 1950 the share of coal had risen to 73 percent of the total and that of oil and gas had dropped to less than 20 percent. The ten-year plan for the development of the oil industry from 1951 to 1960 called for a gradual reduction in the consumption of fuel oil in metallurgical industries, at power plants, and by railroads until in 1960 such uses of fuel oil were to be completely eliminated. However, this plan was scrapped abruptly in 1957 and a new fifteen-year plan was launched with goals for 1972 as stated above.[1]

Thus, the Soviets have begun an exploitation of oil and gas reserves that promises to revolutionize technology in many of their industries and to influence the domestic lives of millions of their citizens. This program should be viewed not merely as a quantitative expansion of oil and gas extraction, but as a fundamental qualitative change in the industrial structure of the country and in the lives of the people. Therefore, inasmuch as is possible, this paper will treat the expanded oil and gas production from the viewpoint of consumption and the effects of this consumption on other facets of life and economic production, rather than from the viewpoint of reserves and production, although a lack of data sometimes will tend to negate this approach; generally, statistics on consumption and transport are in no way as adequate as those on production and reserves.

The paper will deal primarily with the oil and gas industries in the U.S.S.R. since 1950, concentrating on the achievements and goals during the seven-year-plan period, 1959–65. In some instances the future can be projected to 1972, and sometimes it will be necessary to go back beyond 1950 in order to place present developments in correct perspectives. In all cases an attempt will be made to emphasize production and consumption patterns at the expense of geological considerations of deposits. Oil deposits and estimates of reserves have been covered quite adequately in Heinrich Hassmann's *Oil in the Soviet Union*, and in some of the American oil journals. Such information will not be reiterated here. Only more recent estimates and locations will be cited briefly, to bring Hassmann up to date,

[1] The fifteen-year plan calls for the following production in 1972: coal between 650,000,000 and 750,000,000 tons, oil between 350,000,000 and 400,000,000 tons, and gas between 270,000,000,000 and 320,000,000,000 cubic meters. This means that in 1972 oil and gas are to account for more than 60 percent of total fuel consumption while coal is to account for only about 30 percent. I. Kuzmin, "The Reorganization of the Management of Industry and a New Upsurge of the Soviet Economy," *Pravda*, April 5, 1958, pp. 4–5; and M. Brenner, "Problems of Oil in Long-Range Development of the National Economy of the U.S.S.R.," *Voprosy Ekonomiki*, No. 2 (February, 1958), pp. 16–29.

and some information on natural gas deposits will be included because most of these deposits have been discovered so recently that they have not been adequately discussed elsewhere.

REASONS FOR THE CHANGE

The decision to rapidly expand the oil and gas industries can be considered as a continuance of a general shift of Soviet economic thinking away from irrational, over-conservative policies of the past to policies based on economic principles. The emphasis on fluid fuels in future consumption patterns can be justified by production costs alone; for the U.S.S.R. as a whole, the cost of production of oil is one-fourth that of coal, in equivalent heat units, and in the dominant Volga–Urals oil-producing area the disparity between the two is even greater. There is a further two-fold economy in transport: (1) pipe-lines will relieve the railroads, and (2) the conversion of railroad locomotives to Diesel and electric traction will greatly reduce the need for long coal hauls and will increase the efficiency and power of the locomotives.[2] Also, the development of the oil and gas industries will provide a broad base for the badly needed development of all aspects of the chemical industry, including the full range of detergents, plastics, and synthetic fibers, which will provide for, among other things, many new consumer items.

Defense preparedness, through modernization of equipment and development of strategic industries, might have been of some influence, too, in making the decision to rapidly expand oil and gas industries, but one does not have to look beyond purely economic considerations for the reasons. The present policy is a response to the demands of a market with a rapidly developing technology and is based on considerations of relative costs and most efficient uses of critical materials, including transport equipment.[3] The oil and gas share of total fuel consumption planned by the Soviets for 1972 corresponds almost exactly to the role of oil and gas in the United States' fuel consumption in 1955, and is indicative of a fuel ratio more nearly geared to present-day technology of a highly industrialized economy.[4] The 1972 goal for oil production in the U.S.S.R. represents about a 400 percent increase over 1957 production and is of the same order of magnitude as 1958 production in the United States, and the 1972 goal for gas production in the U.S.S.R. represents about a 1500 percent increase over 1957 production and also approximates the 1958 production in the United States.[5]

That the goal for oil production is within the realm of possibility can be seen from the fact that the percentage rate of increase projected for the period 1959–65 is somewhat lower than that achieved during 1945–58, although the absolute increase is somewhat higher (see Fig. 5). Such rapid expansion has been made possible by a training of adequate numbers of technicians with advanced "know-how," a systematic exploration for new reserves of oil and gas, and an increased availability of steel for wells, pipes, and other necessary construction. The existence of the necessary level of development of these basic

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[2] *Izvestia*, November 21, 1958, p. 3.

[3] The total saving by the substitution of natural gas and oil fuel for coal in the next seven years has been estimated to be 125,000,000,000 rubles, which is equal to the appropriations for the construction during the period of all power stations, power transmission grids, and heating systems (*Pravda*, January 28, 1959, p. 1). The cost of hauling one ton of conventional fuel to Sverdlovsk in the form of fuel oil from Ufa is only one-third that of hauling coal from Kuznetsk (*Izvestia*, November 21, 1958, p. 3). The production of ethyl alcohol from natural gas and oil by-product gas will release great quantities of potatoes, grain, and treacle to other uses, and at the same time will be considerably cheaper. The manufacture of one ton of ethyl alcohol requires 2 tons of liquefied gas or 4 tons of grain, 10 tons of potatoes, or 14 tons of sugar beets. To produce one ton of synthetic rubber, 5 tons of liquefied gas are required or 9 tons of grain, 22 tons of potatoes, or 30 tons of sugar beets (*Pravda*, February 7, 1958, p. 2). The quantity of synthetic rubber now being produced at the Sumgait plant, northwest of Baku, using gas and oil products as a base, would require more than the annual crop of all vegetables and grain in Azerbaidzhan (*Izvestia*, November 22, 1958, p. 2). It has been calculated that the utilization of by-product gases of oil extraction for synthetic rubber, instead of alcohol, will save 1,300,000,000 rubles in the next seven years (*Pravda*, November 14, 1958, p. 1).

[4] Brenner, *op. cit.* According to Brenner, the mineral fuel balance for the U.S.A. in 1955 was coal 33 percent, oil 39 percent, and gas 28 percent. This checks fairly well with *The Minerals Yearbook for 1956*, Vol. II, *Fuels*, p. 7, which states that total energy consumption in the U.S.A. in 1956 was: coal 28.4 percent, oil 41.5 percent, gas 26.3 percent, and water power 3.8 percent.

[5] *Pravda*, November 14, 1958, p. 1, and *The United Nations Statistical Yearbook*.

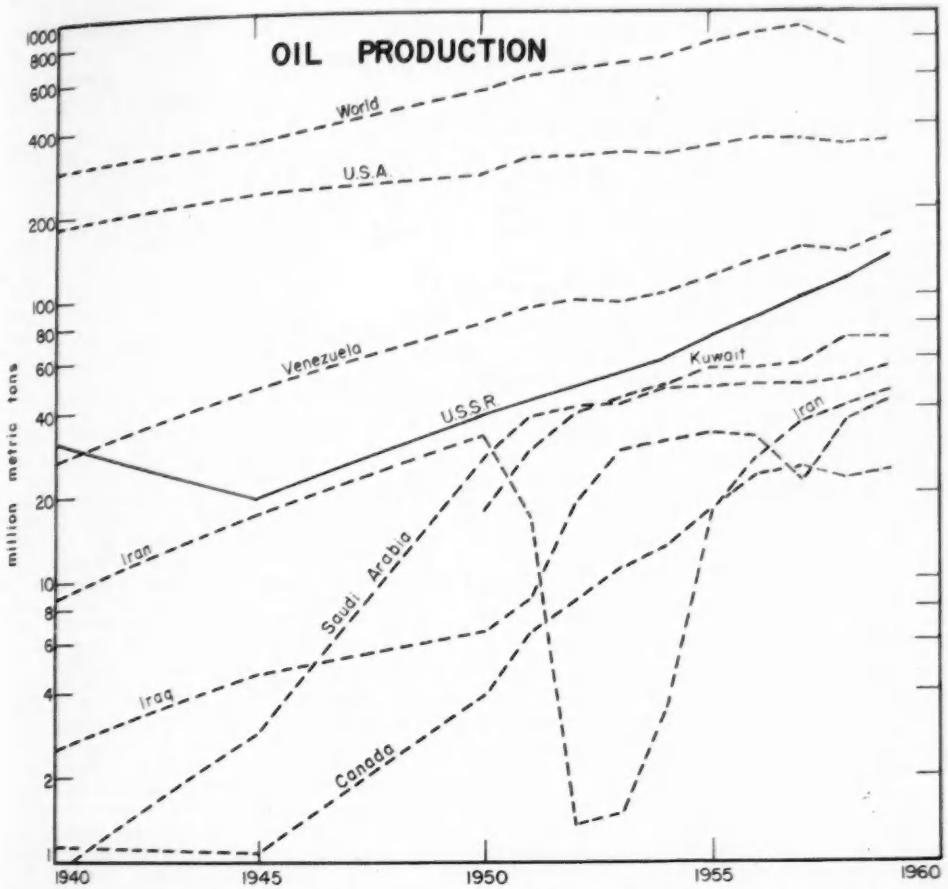

FIG. 1. Oil production of leading oil-producing countries, 1940–59. Data from *United Nations Statistical Yearbook* and the *United Nations Monthly Bulletin of Statistics*. The 1958 and 1959 production figures for the U.S.S.R. are from *Pravda*, November 14, 1958, and January 22, 1960. Note that the above graph has been plotted on semilogarithmic coordinates, and hence the slopes of the lines represent percentage rates of increase.

factors has been proved by performance during the last few years, but the explosive expansion of productivity was released by a sudden awakening of the market by governmental decree.

The change to a trend rapidly to expand oil and gas industries was detectable before the policy was stated explicitly. As can be seen in Figures 1 and 2, the annual rates of increase of production in the U.S.S.R. show a significant increase for oil beginning in 1954 and a very great increase for gas beginning in 1955. In absolute terms, the average annual increase in oil extraction in the U.S.S.R. during the period 1950–54 was 5.3 million metric tons, while during the period 1955–58 it was 14.1 million metric tons. The latter rate of increase is somewhat greater than that for the world as a whole, and much greater than that for the United States. During the seven years 1959–65, oil extraction in the U.S.S.R. is to increase at an annual rate of 16.7–18.1 million metric tons.[6] Judging from these rates of change, Brenner predicts that the Soviet share in world production will rise from 12.5 percent in 1958 to 20–22 percent in 1965, and will pass

[6] Brenner, *op. cit.*

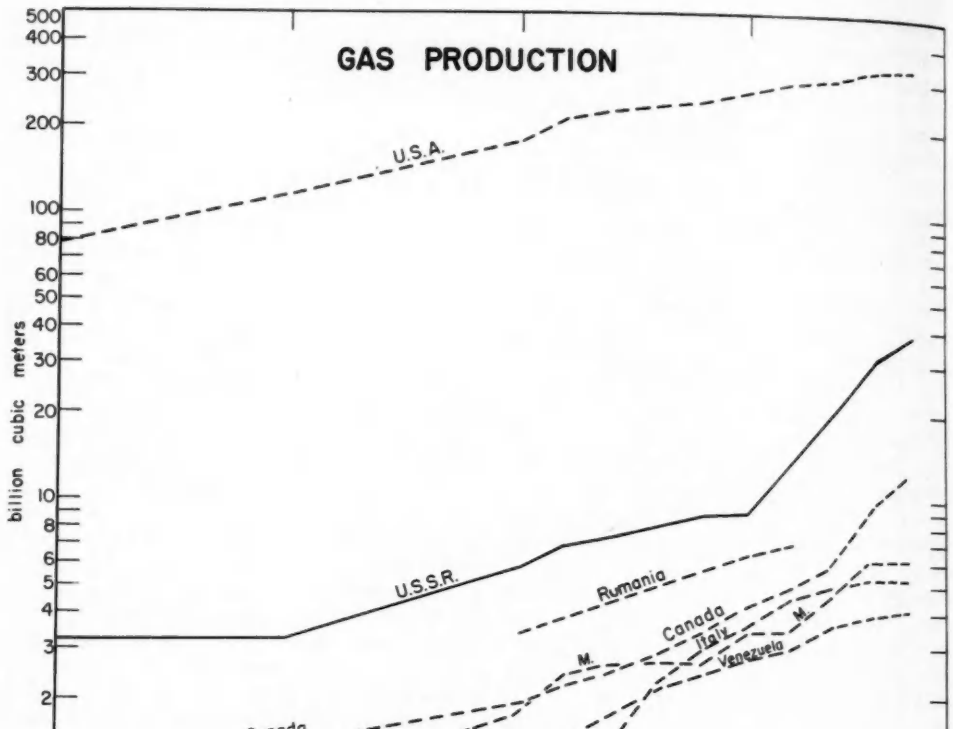

FIG. 2. Natural gas production of leading producing countries, 1940–59. Data for countries other than the U.S.S.R. are from the *United Nations Statistical Yearbook* and the *United Nations Monthly Bulletin of Statistics*. Data for the U.S.S.R. are from *Promyshlennost' SSSR* (1957), pp. 55–99, 156; *Narodnoye khozyaystvo SSSR v 1956 g.*, p. 60; *Dostizheniya sovetskoy vlasti za 40 let* (1957), p. 89; and *Pravda*, January 15, 1956, January 27, 1958, November 14, 1958, and January 22, 1960.

the production of the United States in early 1972.[7] The intention has been stated to increase the oil output in the Soviet Union by 3.5 to 4 times after 1972.[8] One might infer, from the lack of any further statement, that this is the level of production that is envisioned as the ultimate need for the Soviet-bloc countries.

It appears that the factor that might limit expansion of the oil and gas industries during the next several years is the lack of facilities to utilize production efficiently. One of these facilities is the pipeline network; scattered reports have appeared that movement of crude oil from fields to refineries has been delayed in the Volga–Urals area because of lack of sufficient branch lines, that the Stavropol'–Moscow gas line and the Ufa–Omsk crude-oil line are operating inefficiently with only one-third the designed pumping capacities installed, that storage facilities for oil are inadequate in many refining centers, etc. Household appliances and other fixtures to use natural gas often have been found lacking after a supply line has been brought into a district. Even in older areas of gas consumption, such as in the Andizhan region in the Fergana Valley, where oil-field gas has been used for twenty years or more, and where natural

[7] M. Brenner, "Some Economic Problems in the Development of the Petroleum Industry of the U.S.S.R.," *Voprosy Ekonomiki*, No. 1 (January, 1959), pp. 67–73.
[8] *Pravda*, December 4, 1958, pp. 2–3.

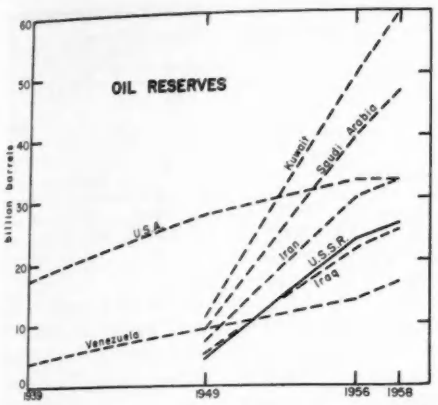

FIG. 3. Oil reserves for leading countries. In 1939, total reserves of the Middle East were estimated at 7 billion barrels. In 1958 the Middle East was estimated to have 62 percent of the world's reserves; the U.S.A., 12.7 percent; the U.S.S.R., 11.0 percent; and Venezuela, 6.7 percent. In 1939, the Sino-Soviet Bloc (which had no meaning then) was estimated to have 5.7 billion barrels. Eugene Stebinger, in *World Geography of Petroleum*, has estimated that, on the basis of suitable sedimentary area for oil production, the U.S.S.R. should eventually produce 68 percent more oil than the U.S.A. In the above graph, to Kuwait and Saudi Arabia might be added the Kuwait Neutral Zone, which in 1956 had reserves estimated at 0.65 billion barrels and in 1958, 6 billion barrels. In 1939, world reserves were estimated at 37.4 billion barrels; in seven years, from 1949 to 1956, world reserves rose from 77.6 to 231 billion barrels. In mid 1958, world reserves were estimated at 265.7 billion barrels. Data for 1939 from *Management Newsletter*, Standard Oil Company of California, December, 1958; for 1949 from Wallace E. Pratt and Dorothy Good, *World Geography of Petroleum* (1950), pp. 22–23; and for 1956 and 1958 from Paul Swain and Ray Gibson, *World-Wide Oil*, an annual report of *The Oil and Gas Journal*, December 31, 1956, pp. 105–06, and December 29, 1958, pp. 87–88.

gas has now become available, only 20 percent of the households are equipped to use gas.[9]

OIL RESERVES AND EXTRACTION: U.S.S.R. AS A WHOLE

Along with production goals, the Soviets have stated the desire to maintain a ratio of 25 or 30 to 1 of proved reserves over annual extraction. To achieve this, hundreds of geological surveying parties have been maintained in the field. As a consequence, 1955 proved oil reserves were almost five times

[9] *Pravda*, December 14, 1958, p. 2, and December 23, 1958, pp. 2–3; *Sovetskaya Rossiya*, July 8, 1958, p. 2.

TABLE 1.—OIL PRODUCTIVITY PER WELL, U.S.S.R. VS. U.S.A., 1955[1]

Production item	U.S.S.R.	U.S.A.
Average daily output per well (tons)	6	1[2]
Annual output per new well (tons)	3210	500[3]
Amount of drilling per ton increase in oil output (meters)	0.2	3

[1] Source: M. Brenner, "Problems of Oil in Long-Range Development of the National Economy of the U.S.S.R.," *Voprosy Ekonomiki*, No. 2 (February, 1958), pp. 16–29.

[2] American sources of information indicate that average daily output per well in the U.S.A. in 1955 was somewhere between 1.5 and 2.0 tons.

[3] In the U.S.A. output per new well is restricted by prorationing. Without restriction the figure might be 30 percent higher. These higher figures probably should be compared with Soviet figures in the calculation of "meters drilled per ton increase of oil output or capacity." However, some such restrictions on production inherently might exist in the Soviet system of unified field development.

those of 1945.[10] More than 700 new oil and gas fields have been discovered in the last ten years. In 1957, the U.S.S.R.'s proved oil reserves of 23 billion barrels were estimated to be approximately 15 percent of the proved world reserves.[11]

Twenty thousand new wells are to be driven in the U.S.S.R. during the seven-year-plan period. This compares with 27,000 new wells in the U.S.A. in 1957 alone; yet the 1957 extraction of oil in the U.S.A. increased very little over that in 1956. The Soviets have a much higher output per well than does the U.S.A. and a much lower volume of drilling per ton increase in oil output, although neither the U.S.A. nor the U.S.S.R. compares favorably in these respects with some sections of the Middle East.

Production per well in the U.S.S.R. has been increasing rapidly, particularly in the Volga–Urals area. This increase has been attributed to contour flooding, to which the Volga–Urals area is particularly adaptable. As new oil wells are drilled in the top of the oil-bearing structure, holes are driven down slope on the rock structure completely surrounding the field, and water is forced in at approximately the same rate at which oil is extracted, thereby maintaining the pressure and eliminating or

[10] A. A. Keller, *Neftyanaya i gazovaya promyshlennost' SSSR v poslevoyennyye gody* (Moscow: Gostoptekhizdat, 1958), p. 6.

[11] *World Petroleum Report*, January 15, 1958, p. 200. In view of the great increases in proved reserves established in the Middle East during the past ten years, this estimate appears to be exaggerated.

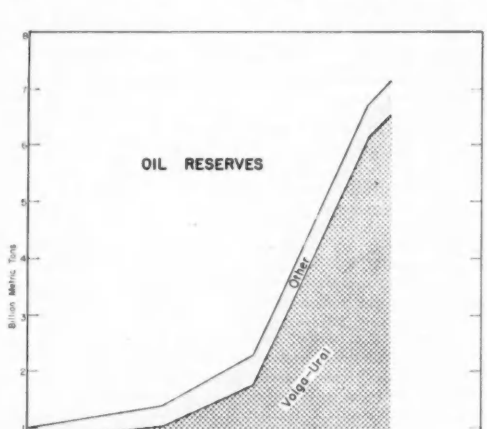

FIG. 4. Oil reserves by regions within the U.S.S.R. (Proved, or A and B, categories only, as defined by Decree of the Council of the People's Commissars of the Soviet Union, February 14, 1951, and listed in Heinrich Hassmann, *Oil in the Soviet Union* [1953], p. 151). Data calculated from information contained in F. F. Dunayev, *Ekonomika i planirovaniye neftyanoy promyshlennosti SSSR* (Moscow: Gostoptekhizdat, 1957), p. 35, and A. A. Keller, *Neftyanaya i gazovaya promyshlennost' SSSR v poslevoyennyye gody* (Moscow: Gostoptekhizdat, 1958), p. 607. Since the base used for calculating absolute values from index numbers is somewhat questionable, the values in terms of billions of metric tons may be in considerable error, but this does not alter the percentage relationships that can be derived from the graph.

reducing pumping, as well as increasing ultimate recovery. It is now planned to bring water 120 kilometers from the Kama River for contour flooding in the Tatar A.S.S.R.[12]

OIL RESERVES AND PRODUCTION BY REGIONS WITHIN THE U.S.S.R.

The oil surveys during the fifteen-year period 1940–55 produced a complete change-

TABLE 2.—OIL WELL PRODUCTIVITY BY YEARS IN THE U.S.S.R.[1]

Years	Average number of new wells each year	Average annual increase of oil (millions of tons)	Increase per new well (tons)
1936–40	1450	1.2	830
1951–55	2290	6.6	2890
1956–57	2072	13.6	6550

[1] Source: *Izvestia*, November 21, 1958, p. 3.

[12] *Pravda*, December 14, 1958, p. 2.

TABLE 3.—REGIONAL DISTRIBUTION OF PROVED RESERVES, IN PERCENT OF TOTAL[1]

Region	1940	1946	1950	1955
Volga–Urals	16	30	53	81
Caucasus	80			15
Azerbaidzhan	61	42	28	11
Others	4			4

[1] Sources: A. A. Keller, *Neftyanaya i gazovaya promyshlennost' SSSR v poslevoyennyye gody* (Moscow, 1958), p. 6, and E. F. Dunayev, *Ekonomika i planirovaniye neftyanoy promyshlennosti SSSR* (Moscow, 1957), p. 173.

over in the distribution of proved reserves by major regions (Fig. 4). Whereas in 1940 the Caucasus contained 80 percent of the known reserves, in 1955 the Volga–Urals region contained 81 percent.

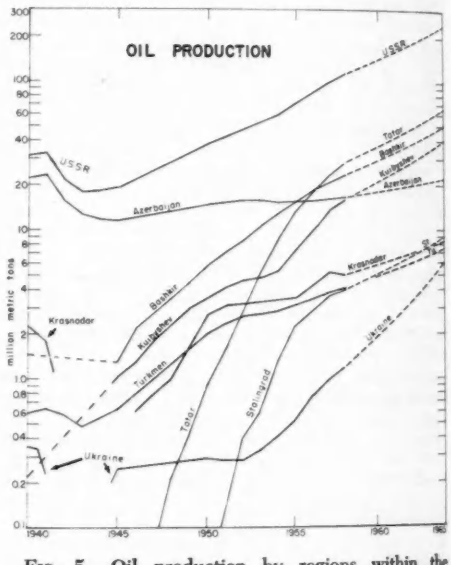

FIG. 5. Oil production by regions within the U.S.S.R., 1940 to 1965. During World War II, oil production in the Ukraine and in Krasnodar Kray was interrupted by the German occupation. It is not certain how much oil was extracted in these areas by either the Germans or the Soviets during the years 1940 to 1945; therefore, the lines on the graph are discontinuous during this period. One Russian source indicates that production at Krasnodar fell to 0.2 million metric tons in 1943. During the same period, production in the Bashkir Republic and in Kuibyshev Oblast probably continued along the trends indicated by the dashed lines representing those two areas on the graph, but the only data available are for the years 1940 and 1945. Data for the minor producing areas of Perm, Komi, Dagestan, Orenburg, Sakhalin, Fergana, Kazakhstan, Saratov, and Grozny have been omitted from the graph for the sake of clarity. Sources: Same as those for Table 4.

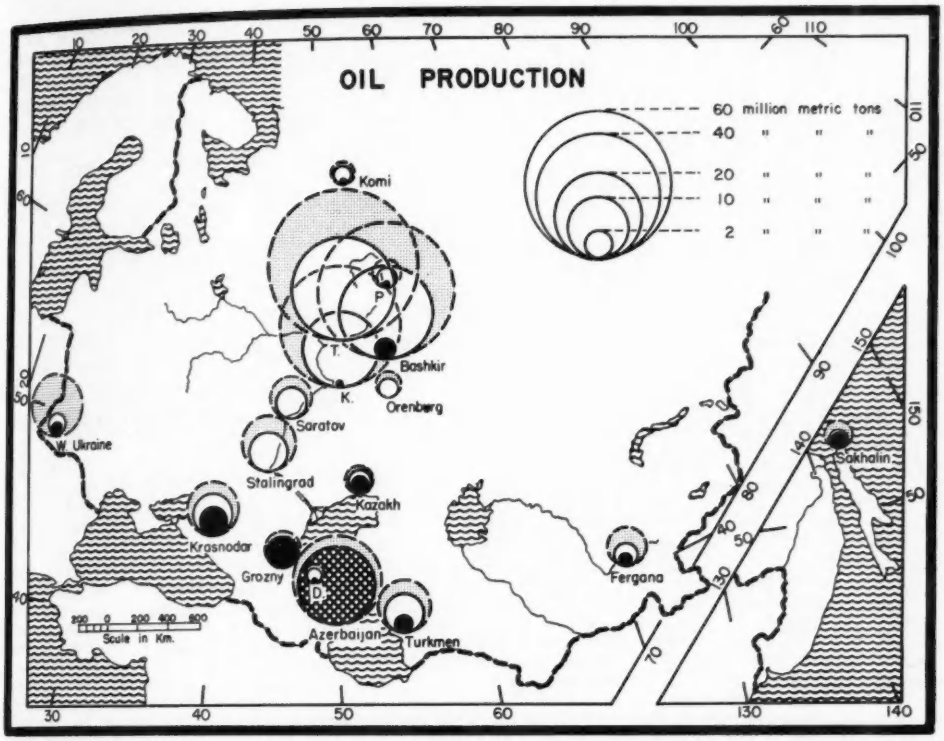

FIG. 6. Oil production by regions within the U.S.S.R., 1940 to 1965. Inner black circles represent production in 1940; intermediate white circles, 1958; and outer stippled circles, 1965 plan. The Azerbaidzhan area presents a problem cartographically, since its 1940 production was almost identical with its planned production for 1965 and more than 1958. The set of small circles and the "D" inside the Azerbaidzhan circles represent the Dagestan production. K = Kuibyshev, T = Tatar, P = Perm. Sources: Same as those for Table 4.

The Volga–Urals reserves lie in nearly horizontal strata in the heart of the country between the Central Industrial Region and the industrial Urals at a strategic point on the main waterway and railway systems. Costs of exploitation and distribution thereby are at a minimum, and consequently a great shift in production has taken place from the old Baku and North Caucasus centers to the Volga–Urals (see Figs. 5 and 6 and Tables 4 and 5).[13]

The production conditions in the Volga–Urals are such that capital costs per ton of crude oil are only one-third of the average costs per ton for all U.S.S.R. fields and only 15 percent of some fields. The effectiveness of investments in the Volga–Urals area is well illustrated by Table 6. During the same period (1946–56), the Volga–Urals area used 20 percent of the total investments in surveying and accounted for 85 percent of the increase in oil reserves.[14]

[13] Between 1950 and 1956, oil extraction rose 120 percent in the U.S.S.R., 240 percent in the RSFSR, and 1,980 percent in the Tatar A.S.S.R. (*Pravda*, December 14, 1958, p. 2). During the period 1951–57, the total U.S.S.R. increase in oil production was accounted for as follows: Tatar A.S.S.R., 37 percent; Bashkir A.S.S.R., 27 percent; Kuibyshev Oblast, 14 percent; Stalingrad Oblast, 6 percent; Saratov Oblast, 4 percent; and other areas, 12 percent (Brenner, "Problems of Oil . . . ," *op. cit.*). Baku production dropped from 22.2 million metric tons in 1940 to 11.5 in 1945, and has been recovering slowly since then, mainly by drilling deeper sections and off-shore deposits beneath the Caspian Sea. Planned 1965 production for Baku is approximately equal to the 1940 production.

[14] Brenner, "Problems of Oil . . . ," *op. cit.*

TABLE 4.—OIL PRODUCTION BY REGIONS WITHIN THE U.S.S.R., IN MILLIONS OF METRIC TONS[1]

	1940	1945	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1965	1972
U.S.S.R.	31.1	19.4	37.9	42.3	47.3	53.8	59.3	70.8	83.8	98.3	113	130	144	235	350–400
R.S.F.S.R.	7.0	5.7	18.2	21.8	26.1	31.4	38.2	49.3	61.3	74.6	88	103	116	192	
Volga–Urals	1.8	2.8	11.0					40.5							
Tatar A.S.S.R.	—	—	0.9					13.2		23.2	28.5			65.0	
Bashkir A.S.S.R.	1.5	1.3	5.8					15.3		20.8	23.4			50.0	
Kuibyshev Oblast	0.2	1.0	3.5					7.3		13.5	16.0			40.0	
Stalingrad Oblast	—	—	—					2.3		3.6	4.0			9.0	
Saratov Oblast	—	—	0.4					1.8		2.8	3.0				
Orenburg Oblast	—	0.4	0.6												
Perm Oblast	0.1	0.2	0.3												
North Caucasus	4.6	1.9	6.4					6.5							
Krasnodar Kray	2.2	0.4	2.7					3.5		5.2					
Chechen-Ingush A.S.S.R.	2.3	1.4	3.2					2.8							
Dagestan A.S.S.R.	0.1	0.1	0.5					0.2							
Sakhalin Oblast	0.5	0.8	0.6					1.0							
Komi A.S.S.R.	0.1	0.2	0.2					0.6							
Azerbaidzhan S.S.R.	22.2	11.5	14.8	15.3	15.7	15.7	15.2	15.3	15.6	16.0	16.6	17.1	17.8	22.0	
Ukraine S.S.R.	0.4	0.3	0.3	0.3	0.3	0.3	0.4	0.5	0.8	1.0	1.2	1.6	2.0	6.0	
Turkmen S.S.R.	0.6	0.6	2.0	2.4	2.7	2.7	2.9	3.1	3.4	3.8	4.1	4.6	5.0	7.5	
Fergana Valley	0.2	0.5	1.4	1.3	1.2	1.1	1.1	1.1	1.2	1.5	1.6			4.5	
Kazakh S.S.R.	0.7	0.8	1.1	1.3	1.4	1.4	1.4	1.4	1.4	1.4	1.5	1.5	1.6	2.0	

[1] Sources: *Promyshlennost' SSSR, 1957*, pp. 72, 77, 79, 83, 91, 93, 97, 153, and 155; *Narodnoye khozyaystvo SSSR v 1956 g.*, pp. 69, 75; M. M. Brenner, *Neft'* (Moscow: Gospolitizdat, 1957), pp. 26, 100; M. A. Yevseyenko, *Neftyanaya promyshlennost' SSSR v shestoy pyatiletke* (Moscow: Gostoptekhizdat, 1957), p. 19; A. A. Trofimuk, *Uralo–Povolzhye—novaya neftyanaya baza SSSR* (Moscow: Gostoptekhizdat, 1957), pp. 156–58; S. M. Lisichkin, *Ocherki razvitiya neftedobyvayushchey promyshlennosti SSSR* (Moscow: Akademiya Nauk, 1958), p. 312; *Narodnoye khozyaystvo Stalingradskoy oblasti* (Saratov, 1957), p. 29; *Narodnoye khozyaystvo Tatarskoy ASSR* (Kazan', 1957), p. 31; Ya. Feigin, "Distribution of Productive Forces in the USSR," *Voprosy Ekonomiki*, No. 10 (1957), p. 75; M. M. Brenner, "Problems of Oil . . . ," *op. cit.*, p. 21; *Razvedka i okhrana nedr*, No. 11 (1957); *Neftyanoye khozyaystvo*, No. 2 (1948), p. 3, and No. 11 (1957), pp. 10, 112; *Pravda*, March 8, 1947, January 8 and December 20, 1948, January 27, 1949, March 30, April 7, and May 5, 1951, March 2 and April 12, 1952, December 6, 1954, February 20, 1956, January 27, November 14, and December 14 and 24, 1958, January 10 and 16, February 3, 4, and 5, March 16, and October 28, 1959, and January 22, 1960; *Izvestia*, March 8, 1947, April 29, 1954, February 8 and 9, 1957, January 17 and March 14, 1958; *Sovetskaya Rossiya*, March 14, 1957, January 30 and November 15, 1958, January 17 and November 25, 1959, and January 23, 1960; *Pravda Ukrainy*, February 2 and December 30, 1958, January 17 and 21, and November 19, 1959, and January 31, 1960; *Kazakhstanskaya Pravda*, February 11 and December 30, 1958, January 24, February 8, and November 19, 1959, and January 27, 1960; *Pravda Vostoka*, February 20, 1958, January 6, 8, and 23, 1959; *Sovetskaya Kirgiziya*, February 16, 1958, January 13, 1959; *Turkmenskaya Iskra*, November 30, 1958, January 8 and November 27, 1959, and February 2, 1960; *Bakinski Rabochi*, December 17, 1955, January 23 and November 26, 1958, January 9 and November 26, 1959, and February 6, 1960.

NATURAL GAS RESERVES AND PRODUCTION

But it is natural gas discovery and production that has been really outstanding; while capital investment in the U.S.S.R. in the oil industry in 1958 increased 15 percent over 1957, in the gas industry it increased 48 percent. As can be seen in Figure 2, gas production took a sharp upward trend beginning in 1955, and according to plan this trend is to be sustained throughout the next fifteen or more years. Until about 1950 little natural gas was produced; most of the gas produced was

TABLE 5.—U.S.S.R. OIL PRODUCTION BY REGIONS IN PERCENT OF TOTAL[1]

	1913	1940	1950	1955	1956	1957	1958	1965 (plan)
Caucasus	97.0	87.1	56.7	30.0	27.0	24.3	22.2	15.2
Volga–Urals		6.0	29.0	58.0	62.8	66.0	67.0	73.0
Central Asia and Kazakhstan	2.9	4.8	11.8	8.0	7.1	6.8	6.3	6.0
Others	0.1	2.1	2.5	4.0	3.1	2.9	4.5	5.8

[1] Sources: M. Brenner, "Problems of Oil . . . ," *op. cit.*, pp. 16–29; Brenner, "Some Economic Problems of the Development of the Petroleum Industry of the USSR," *Voprosy Ekonomiki*, No. 1 (January, 1959), pp. 67–73; and others.

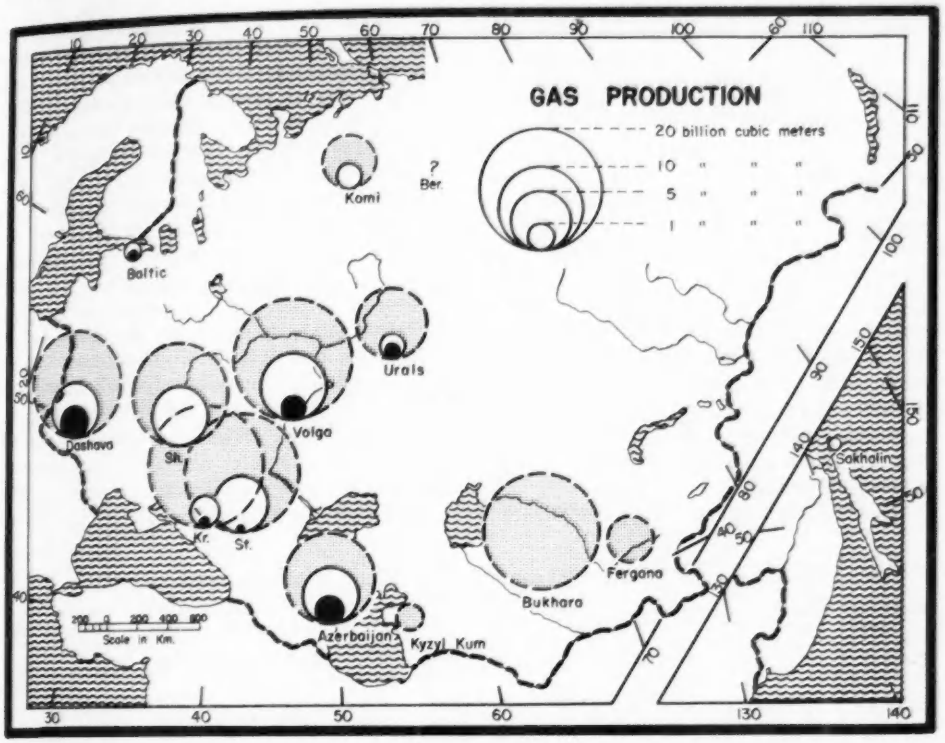

FIG. 7. Gas production by regions within the U.S.S.R., 1950 to 1965. Inner black circles represent production in 1950; intermediate white circles, 1958; and outer stippled circles, 1965 plan. Sh. = Shebelinka, Kr. = Krasnodar, St. = Stavropol', Ber. = Berezovo. There are indications that the Berezovo fields have been given a low priority and might not be developed before 1965. For the Baltic area and for Sakhalin, neither of which has a significant production of natural gas, 1965 plan data indicate that production of gas from shale and from petroleum development will remain essentially the same as in 1958. Komi production in 1958 was approximately the same as in 1950, and the two years are shown on the map by only one circle. The Emba oil fields produce about 0.1 billion cubic meters of gas annually, which is too small an amount to be represented on the map. A potential gas-producing area, which is not shown on the map, is Tas-Tumus, near the confluence of the Vilyui and Lena rivers. A pipeline is to be built from there to Yakutsk by 1965, and a limited gas production to satisfy the market in the Yakut Republic is postulated.

Sources: *Promyshlennost' SSSR*, pp. 55–60, 62, 64–66, 71–72, 79, 83, 89, 97, 99, and 156; *Narodnaya khozyaystvo SSSR v 1958 g.*, p. 60; *Narodnaya khozyaystvo RSFSR*, pp. 22, 25, 28, and 39; *Narodnaya khozyaystvo Estonskoy SSR*, p. 49; *Narodnaya khozyaystvo Latviyskoy SSR*, p. 38; *Dostizheniya sovetskoy vlasti za 40 let* (1957), p. 89; *RSFSR za 40 let* (1958), pp. 156 and 178; *Dosyagneniya radyans'koy Ukrayni za 40 rokiv* (1957), p. 43; *Pravda*, January 15, 1956, January 27, August 31, November 14, and December 5, 1958, and January 10 and February 3 and 5, 1959; *Sovetskaya Rossiya*, February 24, 1957, January 29 and 30 and December 27, 1958, and December 28, 1959; *Pravda Ukrayny*, February 2, 1958 and January 10 and 11, 1959; *Pravda Vostoka*, November 1, 1957 and January 8, 1959; *Bakinski Rabochi*, January 20, 1956, February 2, 1957, January 23 and September 5, 1958, and January 9 and February 2, 1959; Yu. Bokserman and others, *Gazovyye Resursy SSSR* (Moscow, 1959), pp. 65–67.

by-product gas of oil production and refining, and until the Second World War this gas was not utilized, except in the Baku area. Gas was burned off in open flares in most oil fields. Natural gas production increased by only two billion cubic meters during the entire fifth five-year plan (1950–55); 1956 showed an increase of 2.5 billion cubic meters, and 1957 almost six billion. From 1958 to 1965 annual production is to increase approximately eight times.

During the last ten years, large natural gas fields have been discovered in many parts of the Soviet Union, until reserves as of January 1, 1959, were estimated at 930 billion cubic meters. This figure compares with 1958 re-

TABLE 6.—EFFECTIVENESS OF INVESTMENTS IN OIL PRODUCTION, BY MAJOR REGIONS, 1946–56[1]

	Percent of all investments in oil	Percent of total USSR increase in crude oil production
Volga–Urals	35	78
Caucasus	44	14
Central Asia—		
Kazakhstan	12	6
Others	9	2

[1] Source: M. Brenner, "Some Economic Problems . . . ," *op. cit.*, pp. 67–73.

serve estimates of around 7,140 billion cubic meters in the United States and 857 billion cubic meters in Canada.[15] The Soviets expect to increase their gas reserves to 3,411 billion cubic meters by the end of 1965 while extracting 559 billion cubic meters of gas during the seven-year period.

It seems that new deposits continually are being discovered and estimates of old deposits are being revised upward. The *Small Soviet Encyclopedia* for 1958 showed the percentage distribution of natural gas reserves in 1940 to be 58.6 percent in the Ukraine, 24.6 percent in the Komi A.S.S.R., 14.3 percent in the Volga regions, and 1.5 percent in the North Caucasus.[16] Now the largest reserves are along the northern Caucasus, in the Ukraine, along the Volga, in the Uzbek Republic near Bukhara, and in Azerbaidzhan near Baku. The 1940 reserves in the Ukraine were totally in the Dashava area in the newly acquired Western Ukraine; the 1959 Ukrainian reserves include a second large deposit, at Shebelinka south of Kharkov. Toward the end of 1958, discoveries of unspecified deposits of both gas and oil in Poltava Oblast, west of Kharkov, were reported.[17] Huge quantities of gas have been discovered in Krasnodar and Stavropol' Krays

TABLE 7.—PRODUCTION OF GAS, IN MILLIONS OF CUBIC METERS (1940 TO 1972)[1]

Region	1940	1943	1950	1955	1956	1957	1958	1959	1965	1972
U.S.S.R.	3219	1852	5760	8979	12069	18583	28063	37200	150000	270000–320000
R.S.F.S.R.	210	730	2867	4290	5659	8773	13728	19800	84960	
Volga–Ural	15	259	1053[2]	1298[2]	1780[2]	2467[2]	4220[2]		26500[2]	
Kuybyshev Oblast		60	433[2]	512[2]	576[2]	665[2]	650[2]		1500[2]	
Saratov Oblast		128	621[2]	763[2]	1004[2]	1095[2]	1570[2]		11000[2]	
Stalingrad Oblast				24[2]	200[2]	717[2]	2000[2]		10000[2]	
Astrakhan Oblast									500[2]	
Northern Caucasus	195	72	64[2]	103[2]	464[2]	2409[2]	4930[2]		38740[2]	
Chechen-Ingush A.S.S.R.	87	28	53[2]	73[2]	91[2]	83[2]	90[2]		30[2]	
Dagestan A.S.S.R.	29	44	10[2]	10[2]	11[2]	11[2]	10[2]		10[2]	
Krasnodar Kray	79	1		18[2]	288[2]	402[2]	530[2]		19700[2]	
Stavropol' Kray				2[2]	74[2]	1913[2]	4300[2]		19000[2]	
Sakhalin Oblast		58		89[2]	112[2]	74[2]	100[2]		160[2]	
Komi A.S.S.R.		340	1076[2]	989[2]	1000[2]	972[2]	1030[2]		3100[2]	
Eastern Siberia									3650[2]	
Azerbaidzhan S.S.R.	2498	1099	1233	1494	2102	3402	4442	4800	11600	
Ukraine S.S.R.	495		1536	2927	3993	6056	9500	11700	31450	
Uzbek S.S.R.	3	9	52	104	112	113	126	200	18300	55000–60000
Kirgiz S.S.R.							1		2070	
Kazakh S.S.R.	4	10	7	25	33	39	42		60	
Turkmen S.S.R.	9	5	65	141	170	193	224		1050	
Estonia S.S.R.									510	

[1] Sources: Yu. Bokserman and others, *Gazovyye Resursy SSSR* (Moscow, 1959), pp. 65–67; *Pravda*, January 22, 1960; *Sovetskaya Rossiya*, January 23, 1960; *Bakinski Rabochi*, January 6, 1960; *Pravda Ukrainy*, January 31, 1960; and *Pravda Vostoka*, January 27, 1960. Production reached a minimum in 1943 after which it increased slowly but steadily until 1955, and then it rose rapidly.

[2] Natural gas only.

[15] *Industrial Gas*, May, 1958, pp. 4–5, says that natural gas reserves in the U.S.A. on December 31, 1957, were 246,569,255 million cubic feet. Canadian gas reserve estimate is from *The Newscaster; A Review of Canadian Natural Resources Developments*, Vol. 20, No. 4 (April 6, 1959).

[16] *Malaya Sovetskaya Entsiklopediya*, Third Edition, Vol. 2 (1958), p. 768.

[17] *Pravda*, December 10, 1958, p. 2.

TABLE 8.—PROVED RESERVES OF NATURAL GAS AS OF JANUARY 1, IN BILLIONS OF CUBIC METERS (1952 TO 1959)[1]

Region	1952	1953	1954	1955	1956	1957	1958	1959
U.S.S.R.	223.0	247.0	342.0	389.0	491.0	588.0	700.0	930.0
R.S.F.S.R.	143.9	156.0	242.1	272.0	344.6	397.6	452.0	550.0
Volga–Urals	26.0	29.0	31.0	36.0	59.4	89.4	110.0	141.0
Kuybyshev and Orenburg Oblasts	6.0	7.0	8.0	10.0	11.0	11.0	11.4	13.0
Saratov Oblast	16.0	14.0	14.0	14.0	24.0	37.0	41.2	52.0
Stalingrad Oblast	4.0	8.0	9.0	12.0	22.0	38.0	52.4	68.0
Astrakhan Oblast						3.0	5.7	8.0
Bashkir A.S.S.R.					0.4	0.4	0.3	
Northern Caucasus	98.2	107.3	93.2	219.2	269.2	286.2	316.6	363.0
Stavropol' Kray	95.0	104.0	175.0	188.0	200.0	215.0	223.5	230.0
Krasnodar Kray		0.1	15.0	28.0	67.0	69.0	90.2	130.0
Chechen-Ingush A.S.S.R.	3.0	3.0	3.0	3.0	2.0	2.0	0.5	2.0
Dagestan A.S.S.R.	0.2	0.2	0.2	0.2	0.2	0.2	0.3	1.0
North Ossetian A.S.S.R.							1.6	
Komi A.S.S.R.	19.0	19.0	17.0	16.0	15.0	14.0	13.6	13.0
Siberia						6.0	9.3	21.0
Sakhalin Oblast	0.7	0.7	0.9	0.8	1.0	2.0	1.5	2.0
Ukraine S.S.R.	69.0	80.0	89.0	103.0	108.0	139.0	164.0	200.0
Azerbaidzhan S.S.R.	7.0	9.0	10.0	10.0	20.0	33.0	52.2	80.0
Turkmen S.S.R.				1.0	15.0	15.0	8.3	8.0
Uzbek	1.0	1.0	2.0	2.0	2.0	3.0	23.0	100.0
Kazakh S.S.R.					.09	0.1		
Tadzhik S.S.R.							0.4	
Kirgiz S.S.R.							0.1	2.0

[1] Source: Yu. Bokserman and others, *Gazovyye Resursy SSSR*, p. 49.

in the North Caucasus and in Saratov and Stalingrad Oblasts along the Volga. The early production of small quantities of gas in Azerbaidzhan was in conjunction with oil production at Baku, but a greatly expanded production has been made possible by the discovery of two large deposits of natural gas, Karadag and Kyanizadag, southwest of Baku. And in the Uzbek Republic an entirely new discovery of natural gas has been made in the desert near Bukhara. Table 10 shows estimates of possible gas reserves in the various regions of the U.S.S.R., and Figure 8 indicates the degree of probability of gas-bearing regions.

FUEL BALANCE: U.S.S.R. AS A WHOLE

According to Notkin, the fuel balance, which remained more or less constant from 1940 to 1955, was prevented, by a mistaken fuels policy, from undergoing an earlier shift away from coal, although the economic advantages of oil and gas were obvious. Erroneous policy resulted, for example, in the development of the Kumertau brown-coal field in the Bashkir A.S.S.R., one of the leading oil areas. The cost of producing this coal was eight times that of producing local fuel oil. Another example is Saratov oil shale, mined at Gornyy and Ozinki, on the left bank of the Volga, which costs 18 times more than natural gas, and which was mined even after the discovery of natural gas in that area. There was a time, 1949–54, when use of gas was prohibited in Saratov industry, and gas output had to be curtailed, while mining of low-calory, high-cost shale increased. Oil shale still is being mined at Kashpirovka, Syzran suburb in Kuybyshev Oblast, which costs almost 10 times more than local fuel oil. Another example is the extraordinary expansion of mining in the Moscow coal basin, which produces some of the most expensive and low-grade coal in European Russia.

In the three-year period 1956–58 a major change in the fuel balance took place: oil output increased 60 percent, and gas more than tripled, while coal output rose only 27 percent. The oil and gas share of mineral fuel production rose from 26.3 percent in 1955 to 33 percent in 1958, and the trend is to continue during the seven-year plan, with the

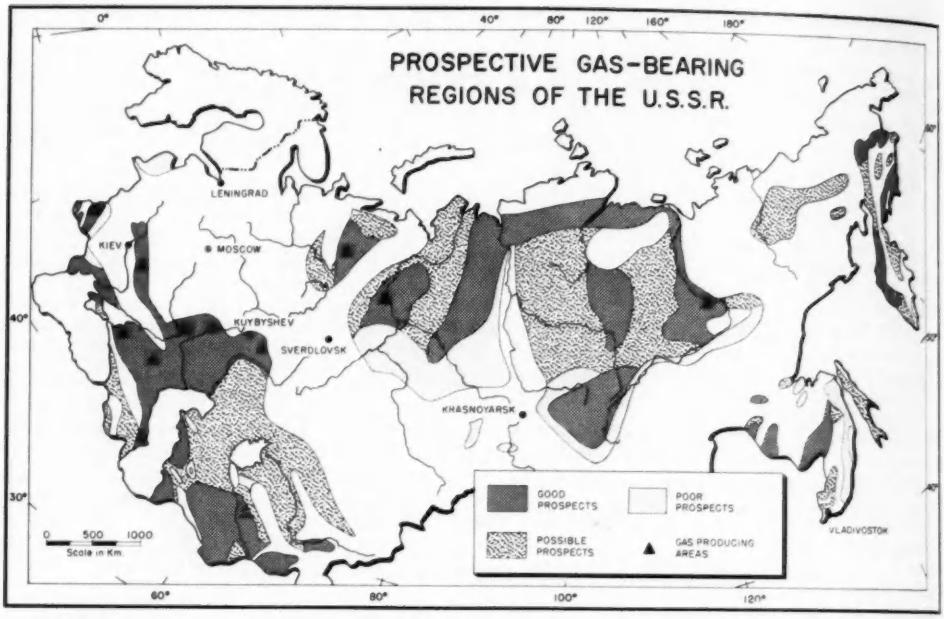

FIG. 8. Prospective gas-bearing regions of the U.S.S.R. Adapted from Yu. Bokserman and others, *Gazovye Resursy SSSR* (Moscow, 1959), facing p. 42.

following increases for major fuels: natural gas, 5.6 times; casinghead gas, 2.8 times; crude oil, more than two times; coal, 20–23 percent; peat, 36 percent; and oil shale, 61 percent. In terms of standard fuel units, this means increases of 168–182 million tons of oil and 143 million tons of gas as compared with an increase of 75–81 million tons of coal. In other words, the oil–gas increase, in equivalent units, is scheduled to be about four times as great as the coal increase.[18] The output of natural gas that is planned for 1965 is equal in thermal effect to the total coal production of the Donets, Moscow, and Pechora basins in 1958.[19]

Exploitation of natural gas, as compared with the opening of new coal fields, is expected to save more than 25 billion rubles in capital investments during the seven-year plan and to cut operational expenses by more than 30 billion rubles; it can release thousands of workers for other types of industry, and it will relieve the railroads. The introduction of new technology and more rational use of fuels during the period is expected to cut fuel consumption by 18 percent over what would be required under present modes of consumption. One way to save fuel will be to increase electric and Diesel traction on railroads and to convert locomotives from coal to fuel oil. By 1965, electric and Diesel locomotives are expected to handle 87 percent of all rail traffic, as compared with 26 percent in 1958.[20]

The share of oil and gas in the total fuel

[18] D. Notkin, "Reshaping the Fuel Balance," *Planovoye khozyaystvo*, No. 1 (1959), pp. 42–52.

[19] *Pravda*, February 7, 1958, p. 2.

[20] The share of coal in total railroad fuel is to drop from 86.5 percent in 1958 to 11.4 percent in 1965, and the share of fuel oil and Diesel fuel during the same period is to rise from 7.4 percent to 51 percent. Conversion of steam locomotives from coal to fuel oil was to have started in 1959, with annual increases of consumption of fuel oil to amount to 4.5–7 million tons. As a result, it was estimated that total coal savings for the seven-year period would be 81 million tons. The conversion to electric and Diesel traction is expected to cut fuel consumption per ton-kilometer in 1965 to about 35 percent of the 1958 level, thereby saving 67 million tons of standard fuel units.

According to the report of Sam H. Schurr before the Energy Resources Committee, 86th Congress, on October 12, 1959, electricity in the U.S.A. increasingly is being generated from coal, resulting in a relative increase of railroad transportation of coal. This fact has led certain American economists to question the Russian claims as outlined above.

TABLE 9.—NATURAL GAS PROVED RESERVES AND PLANNED INCREASES (1959–65), IN BILLION CUBIC METERS[1]

Region	Reserves Jan. 1, 1959	Planned increase 1959–65	Planned production 1959–65	Expected reserves Jan. 1, 1966
Total U.S.S.R.	930	3,040	559	3,411
R.S.F.S.R.	550	1,325	306	1,569
Kuybyshev Oblast	8	25	51	28
Saratov Oblast	52	185	52	185
Stalingrad Oblast	68	200	37	230
Astrakhan Oblast	8	50	18	56
Orenburg Oblast	5	80	12	73
Komi A.S.S.R.	13	70	10	83
Krasnodar Kray	130	260	76	314
Stavropol' Kray	230	150	108	272
Chechen-Ingush A.S.S.R.	2	—	—	2
Siberia (Berezovo and Tas-Tumus)	21	300	4	317
Sakhalin	2	5	1	6
Ukraine S.S.R.	200	550	159	591
Azerbaidzhan S.S.R.	80	250	50	280
Uzbek S.S.R.	100	620	40	680
Turkmen S.S.R.	8	150	2	156
Kirgiz S.S.R.	2	35	2	35
Tadzhik S.S.R.	—	10	—	10
Kazakh S.S.R.	—	100	—	100

[1] Source: M. F. Mirchink, V. G. Vasil'yev and M. S. L'vov, "Principal Trends in the Discoveries of New Deposits and In Increasing Explored Reserves of Oil and Gas," *Neftyanoye khozyaystco*, No. 4 (1959), p. 2, and Yu. Bokserman and others, *Gazovyye Resursy SSSR*, p. 50.

consumption of thermoelectric stations also is expected to increase, despite continued heavy reliance on coal. According to the Soviets, by 1965, twenty thousand kilometers of railroads, all state and collective farms, all Repair and Technical Stations, and all workers' settlements are to be electrified. Oil and gas will play a large part in the increased generation of electricity for these purposes.

Oil and gas will play a greater role in steel furnaces and especially in cement kilns. Petrovsky, Dzerzhinsky, and Zaporozhye steel plants in the Dnieper area use natural gas in open-hearth and blast furnaces and reportedly effect an increase in productivity and a saving of fuel. According to the Soviets, the shifting of more than 50 blast furnaces and a large number of open-hearth and heating furnaces to natural gas and oxygen can increase the steel smelted per year by 2,500,000 tons by 1965. Many of the metal industries are being converted to the use of natural gas, and gas is replacing firewood, kerosene, and coal in domestic use. Table 13 well illustrates the point that gas is expected to become the second most important energy fuel by 1965.

TABLE 10.—POSSIBLE GAS RESERVES, U.S.S.R., BY REGIONS[1]

Area	Billions of cubic meters	Percent of total
U.S.S.R. Total	19,370	100.0
R.S.F.S.R.	11,365	58.7
Volga–Ural Region	2,715	14.0
Kuybyshev Oblast	150	
Orenburg Oblast	460	
Saratov Oblast	820	
Stalingrad Oblast	1,180	
Astrakhan Oblast	105	
Northern Caucasus Region	1,585	8.2
Rostov Oblast	200	
Krasnodar Kray	675	
Stavropol Kray	620	
Chechen-Ingush A.S.S.R.	40	
Dagestan A.S.S.R.	50	
European North	825	4.3
Kaliningrad Oblast	15	
Central & Northern Regions of European U.S.S.R.	90	
Komi A.S.S.R.	720	
Western Siberia	3,630	18.8
Sverdlovsk Oblast	39	
Chelyabinsk Oblast	11	
Tyumen Oblast	2,450	
Omsk Oblast	60	
Novosibirsk Oblast	40	
Tomsk Oblast	550	
Krasnoyarsk Kray (left bank of the Yenisei River and Taimyr Lowland)	450	
Minusinsk Basin	5	
Kemerovo Oblast	25	
Eastern Siberia	2,570	13.3
Irkutsk Oblast	130	
Krasnoyarsk Kray (right bank of Yenisei)	150	
Yakutsk A.S.S.R.	2,290	
Far East	40	.2
Sakhalin Oblast	40	
Ukraine S.S.R.	1,580	8.2
Western Ukraine	400	
Eastern Ukraine	1,030	
Black Sea Coastal Area	150	
Moldavia S.S.R.	20	0.1
Lithuania S.S.R.	10	0.05
Latvia S.S.R.	5	0.02
Kazakh S.S.R.	1,080	5.6
Azerbaidzhan S.S.R.	700	3.6
Armenia S.S.R.	15	0.07
Central Asia	4,595	23.7
Tadzhik S.S.R.	65	0.3
Kirgiz S.S.R.	130	0.7
Turkmen S.S.R.	2,600	13.4
Uzbek S.S.R.	1,800	9.3

[1] Source: Yu. Bokserman and others, *Gazovyye Resursy SSSR*, pp. 43, 45, 46.

TABLE 11.—MINERAL FUEL PRODUCTION IN STANDARD FUEL UNITS, IN PERCENT OF TOTAL (1940 TO 1955)[1]

Year	Coal	Oil	Natural gas	Peat	Oil shale
1940	69.6	21.8	2.0	6.3	0.3
1950	72.6	19.5	2.4	5.1	0.4
1955	68.5	23.7	2.6	4.6	0.6

[1] Source: D. Notkin, "Reshaping the Fuel Balance," *Planovoye khozyaystvo*, No. 1 (1959), pp. 42–52. The Soviet definition of mineral fuels includes peat but not wood.

Although 20 percent of all households are supposed to be using natural gas by 1965, 80 percent of all gas production is ear-marked for industry.[21] One can assume, then, that the most heavily industrialized areas will be the greatest users, regionally speaking. If one further assumes that gas, oil, and coal will be used regionally to best complement one another, then one pretty well can imagine the pattern of regional consumption of mineral fuels that is to be developed.

European U.S.S.R. will increase its fuel consumption at the slowest rate, 34 percent, but its absolute increase, in tons, will be the greatest of all regions, because of the large share of European U.S.S.R. in the nation's total fuel consumption. Fuel consumption in European U.S.S.R. during 1959–65 is scheduled to increase as follows: coal, 7 percent; oil fuel, 100 percent; and gas fuel, 280 percent.[22]

CONSUMPTION PATTERNS, REFINING, AND TRANSPORT OF OIL

Although statistics on oil refining and consumption are in no way as adequate as those available on production, some idea as to present status and trends can be gleaned from scattered reports. Until the last few years, the U.S.S.R. had one of the lower per capita consumptions of oil products among the major countries and a type of consumption that was heavily oriented toward fuel oil and kerosene for various uses in agriculture. As late as 1939, it was reported that of all petroleum products consumed in the Soviet Union, agriculture took 60 percent. This included, in addition to

TABLE 12.—FUEL USE IN ELECTRIC STATIONS AND THE CEMENT INDUSTRY, IN PERCENT OF TOTAL, 1958 AND 1965[1]

Fuel	Electric stations		Cement industry	
	1958	1965	1958	1965
Coal	69.9	61.3	59.3	28.3
Fuel oil	5.9	12.3	3.9	5.4
Gas	10.7	17.2	36.8	66.3
Peat	8.1	5.7	—	—
Shale	0.9	1.2	—	—
Others	4.5	2.3	—	—
Total	100.0	100.0	100.0	100.0

[1] Source: Yu. Bokserman and others, *Gazovyye Resursy SSSR*, p. 11.

[21] *Pravda*, November 14, 1958, p. 1.
[22] Notkin, *op. cit.*

TABLE 13.—EXPECTED PERCENTAGE CHANGES IN THE STRUCTURE OF ENERGY FUELS (NOT COUNTING COKING COAL), 1955 TO 1965[1]

Fuel	1955	1958	1960	1965
Coal	72.9	69.4	63.9	49.2
Oil fuel	10.9	12.1	13.1	17.8
Gas	2.6	7.5	13.1	24.8
Peat	5.1	4.7	7.1	3.6
Oil shale	0.8	1.0	1.1	1.1
Firewood	7.7	5.3	4.7	3.5

[1] Source: D. Notkin, "Reshaping the Fuel Balance," *op. cit.*, pp. 42–52. The fuel balance represented in this table includes only those parts of oil and gas production that directly replace coal, namely, residual fuel oil and Diesel oil used in steamships, locomotives, and power stations. In 1965, for example, only 26 percent of all Diesel fuel is expected to be used in this manner, the rest going into trucks, tractors, and other uses. None of the light fractions (gasoline, kerosene) are included in the fuel balance since they don't replace coal. If one includes coking coal in the above table, the 1965 fuel balance is expected to consist of 36 percent oil and gas, 64 percent solid fuels.

TABLE 14.—TYPES OF FUEL CONSUMPTION BY REGIONS, IN PERCENT OF TOTAL, 1958 AND 1965[1]

Fuel	European U.S.S.R.		Urals		Asiatic U.S.S.R.		U.S.S.R. total	
	1958	1965	1958	1965	1958	1965	1958	1965
Coal	68.1	49.2	80.8	46.6	86.3	82.2	59.0	43.0
Oil	10.9	16.5	11.3	20.5	7.8	7.9	25.0	30.0
Natural gas	9.6	25.3	0.9	28.1	0.9	6.0	6.5	21.0
Peat	6.0	4.7	1.7	1.1	—	0.2		
Shale	1.3	1.6	—	—	—	—		
Firewood	4.1	2.7	5.3	3.7	5.0	3.2	10.0	6.0
Underground gas (from coal)	—	—	—	—	—	0.5		
Total	100	100	100	100	100	100	100	100

[1] Source: Yu. Bokserman, V. Kalamkarov, and A. Kortunov, "Tasks of Development of the Gas Industry," *Planovoye khozyaystvo*, No. 12 (1958), p. 34. Note: Yu. Bokserman and others, *Gazovyye Resursy SSSR*, Table 2, p. 10, shows somewhat different percentage figures for the three regions than are shown in the table above. In all instances, oil and natural gas appear to be more important than is indicated above; this is particularly true with respect to the Urals in 1965. Since both tables originated from the same senior author at approximately the same date, one has no basis for choosing between them.

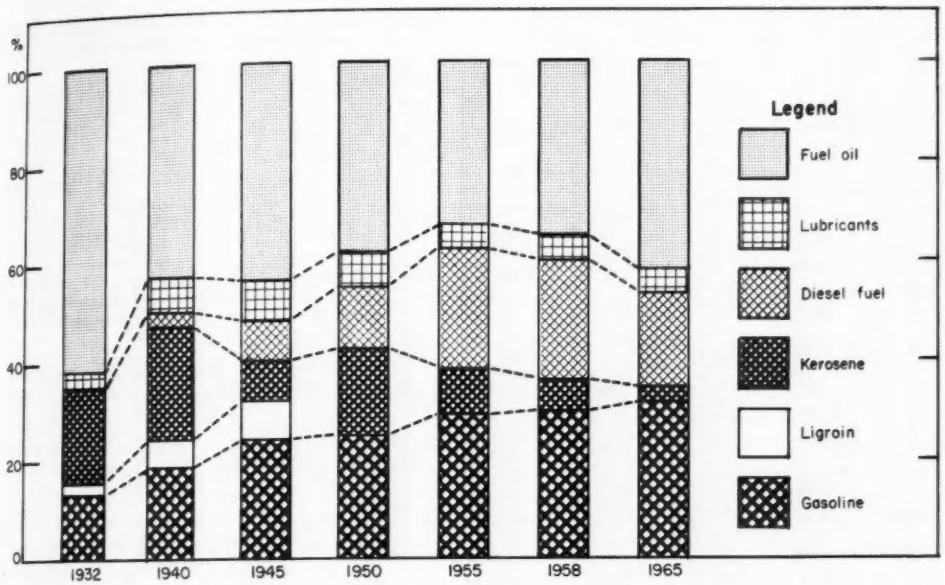

FIG. 9. Petroleum products in the U.S.S.R., 1932–65. Production is given in percentages of totals, for years for which adequate data are available. Figures are only approximate, and "gasoline" includes only gasoline for automobiles; no data have been released on aviation gasoline and jet fuels. Ligroin is a distillate product which was used as a fuel by old Chelyabinsk tractors. Data from *Neftyanaya promyshlennost' SSSR* (Moscow, 1958), pp. 275, 280–82; S. M. Lisichkin, *Ocherki razvitiya neftedobyvayushchey promyshlennosti SSSR* (Moscow, 1958), pp. 204, 217; F. F. Dunayev, *Ekonomika i planirovaniye neftyanoy promyshlennosti SSSR* (Moscow, 1957), p. 42.

the fuel oil, more than 60 percent of the kerosene supply.[23]

But the pattern of consumption is changing as the economy develops in the U.S.S.R. (see Figs. 9 and 10). Kerosene is being replaced by natural gas for domestic heating and cooking, by electricity for domestic lighting, and by Diesel fuel in tractors. And the fraction of total output of oil products that is constituted by gasoline is increasing steadily as automobiles, trucks, and airplanes become a more significant part of the market for oil products. The conversion of many railroad locomotives, steamships, and tractors to Diesel traction and the increased production of heavy Diesel motor vehicles have induced a large growth

TABLE 15.—EXPECTED REGIONAL CHANGES IN FUEL CONSUMPTION, 1958 AND 1965[1]

Region	Percent of total		Percentage increase
	1958	1965	
European U.S.S.R.	64.5	59.1	34
Urals	16.7	16.9	57
Asiatic U.S.S.R.	18.8	24.0	98
Total	100.0	100.0	

[1] Source: D. Notkin, "Reshaping the Fuel Balance," *op. cit.*, pp. 42–52.

[23] Lazar Volin, "Machine-Tractor Stations in the Soviet Union," *Foreign Agriculture*, Vol. 12, No. 4 (April, 1948), p. 85 (quoting K. Chebatarev).

TABLE 16.—PER CAPITA CONSUMPTION OF PETROLEUM PRODUCTS, IN U.S. GALLONS, 1948 AND 1958[1]

Country or area	1948	1958
U.S.A.	593	793
Canada	360	688
Scandinavia	115	406
United Kingdom and Ireland	82	214
Other Western Europe	30	133
Eastern Europe (except East Germany)	13	47[2]
U.S.S.R.	55	182

[1] Sources: 1948 data from *Focus*, American Geographical Society (November 15, 1950); 1958 population data from *United Nations Demographic Yearbook*; 1958 consumption data from *World Petroleum Report*, February 15, 1959, p. 20. The conversion ratio of 42 U.S. gallons per barrel was used.

[2] The 1958 figure for Eastern Europe includes data for only Austria, Greece, and Yugoslavia.

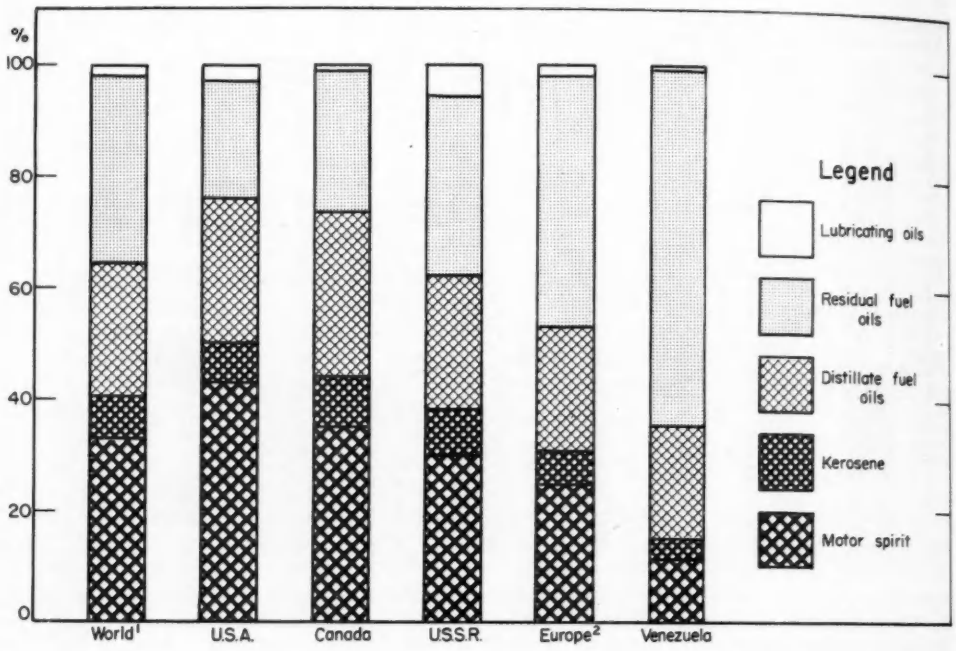

FIG. 10. Petroleum products for some leading refining areas of the world. Production is given in percentages of totals. All data, except those for the U.S.S.R., are from the *United Nations Statistical Yearbook* (1957), pp. 256–61, and are for 1956. For definitions of categories, see data source. Data for the U.S.S.R. are from *Neftyanaya promyshlennost' SSSR* (Moscow, 1958), pp. 281–82, and are for 1955. The categories of products refined in the U.S.S.R. are not exactly equivalent to those used for the other countries. Reading up from the bottom of the bar graph for the U.S.S.R., the categories are respectively: gasoline, kerosene, Diesel fuel, fuel oil, and lubricants. As in Figure 8, aviation gasoline and jet fuels have not been included in the U.S.S.R. total; so the percentage of light fractions shown by the bar graph may be too low. The present ratios of petroleum products in the U.S.S.R. may be closer to those for Canada and the U.S.A. than is shown by the graph. The world bar excludes India, Mainland China, Albania, Czechoslovakia, and the U.S.S.R.; Europe excludes Albania, Czechoslovakia, and the U.S.S.R.

in Diesel fuel production since 1940. From 1946 to 1956, total refining increased 5 times; cracking 5 times; the production of gasoline, 5 times; kerosene, 3.5 times; and Diesel fuel, 20 times.[24] The plan during 1959–65 to convert many thermoelectric plants and many industries to fuel oil will bring about a relative increase in fuel oil production once again, as is indicated in Figure 9. Consumption of petroleum products in the U.S.S.R. by sectors of the economy in 1950 is shown in Table 17. By now, no doubt industry and transportation have become considerably more important in the total oil consumption.

Although new refineries are being built, refining capacity has been lagging behind the production of crude petroleum. This deficiency largely is to be eliminated during 1959–65, according to the Soviets, when capacity for primary oil refining is to increase 110–120 percent; catalytic cracking, 330 percent; and

TABLE 17.—CONSUMPTION OF PETROLEUM PRODUCTS IN THE U.S.S.R., BY SECTORS OF THE ECONOMY, 1950[1]

Sector of economy	Million metric tons
Industry	12
Transportation	10
Agriculture	9
Households	1
Soviet armed forces	8
Total	40

[1] Source: Heinrich Hassmann, *Oil in the Soviet Union* (1953), p. 120.

[24] Brenner, "Problems of Oil . . . ," *op. cit.*

TABLE 18.—REFINING CAPACITY OF U.S.S.R. AND U.S.A., 1949 TO 1958[1] (IN THOUSANDS OF BARRELS PER DAY)

Country	1949	1954	1958
U.S.S.R.			
Crude	973	1246	1800
Cracking	—	389	520
U.S.A.			
Crude	6348	8090	8922
Cracking	—	5631	—

[1] Sources: For 1949 data, *Focus* (1950); for 1954 data, *Petroleum Facts and Figures*, 11th ed., p. 294; and for 1958 data, *World Petroleum Report*, January 15, 1958, p. 14.

reforming, 16–18 times.[25] With the exception of the Caucasian oils, Soviet crudes are heavy, with asphalt bases, and yield only 5 to 10 percent gasoline by straight-run distillation; hence, cracking and reforming installations are highly necessary.[26]

The location and type of refineries to be built depend on the peculiarities of the crude oil to be refined, the type of products to be consumed, and transportation considerations relative to other fuel sources. Before World War II, oil was refined chiefly near producing areas in such cities as Baku, Batumi, and Tuapse; and it was shipped in refined form to consuming areas, the Central Industrial Region and the Ukraine. Principal flow lines for oil products were across the Caspian and up the Volga and across the Black Sea to the Ukraine. The recent expansion of oil production and consumption over the country as a whole has allowed for a great regional shift, percentage-wise, in the oil-refining industry without any absolute reduction of refining capacity in old refining areas. Commensurate with basic economic principles, the new refineries preponderantly are being built in oil-consuming areas, and crude oil is being shipped to them. The seven-year plan provides for the construction of oil refineries in almost all of the main consuming areas (see Fig. 11 and Appendix summary of pipeline development).[27]

An absolute decline in crude output in the Caucasus has left a surplus of refining capacity there, whereas new refinery construction has not been able to keep up with crude production in the Volga–Urals producing area and the associated consuming centers. This fact, together with a fuel-oil shortage in the Caucasus, has induced the flow of some crude

TABLE 19.—REGIONAL DISTRIBUTION OF OIL REFINING, 1940 TO 1955, IN PERCENT OF TOTAL[1]

Region	1940	1946	1950	1955
Caucasus	80.3	66.0	55.8	36.5
Volga–Urals–Center	8.1	21.7	30.1	44.5
Others	11.6	12.3	14.1	19.0

[1] Source: F. F. Dunayev, *Ekonomika i planirovaniye neftyanoy promyshlennosti SSSR*, p. 171. Somewhat different statistics are given in Brenner, *Neft'* (Moscow, 1957), p. 122, which would make the Volga–Urals–Center even more important than it appears in the above table, but the Dunayev figures are more detailed and seem to be more accurate.

TABLE 20.—REGIONAL DISTRIBUTION OF CONSUMPTION OF REFINED PRODUCTS, 1930 TO 1955, IN PERCENT OF TOTAL[1]

Region	1930	1940	1955
East (Urals–Siberia–Kazakhstan)	6.0	18.1	27.2
South (Ukraine–Caucasus–Central Asia)	42.4	47.0	37.4
Center (European R.S.F.S.R.)	53.8	40.9	38.1
Total consumption (million metric tons)	12	27	41

[1] Source: *Neftyanaya promyshlennost' SSSR* (Moscow, 1958), p. 283.

[25] *Pravda*, November 14, 1958, p. 1.

[26] The construction of cracking plants was begun in 1928, and in 1937 cracking capacity was said to be 9.25 million tons. Output from these plants was: gasoline, 1,750,000 tons; kerosene, 1,500,000 tons; and motor and Diesel fuels, 325,000 tons (Heinrich Hassmann, *Oil in the Soviet Union* [Princeton, 1953], pp. 52–53). Plants for direct oil distillation of 45 million tons capacity each and cracking plants of 26 million tons capacity each are to be in operation in 1960. It is planned that eventually plants of hundreds of millions of tons capacity will be built (Brenner, "Problems of Oil . . . ," *op. cit.*).

[27] Essentially new refining industries are to be established in the center and the northwestern parts of European U.S.S.R. and in eastern Siberia. Three new refineries are to be built in the Ukraine. Construction is to be completed on a large new refinery in Uzbekistan, which, together with the existing refinery, will ensure the refining of all oil obtained in the Uzbek and Kirgiz Republics (*Pravda*, November 14, 1958, p. 1). A second refinery is being built in Kuibyshev Oblast (*Izvestia*, December 10, 1958, p. 8). In late 1958, production was initiated in a refinery being built in Moldavia (*Pravda*, January 30, 1958, p. 2). New refineries in Perm and Novo-Gorky, as well as new capacities in existing refineries, went into operation in 1958 (*Pravda*, January 16, 1959, p. 1). The heavily producing areas of Tataria and northwest Bashkiria, which rapidly are becoming consuming areas as well, do not yet have any refineries, much to the distress of the economic councils in those areas (*Pravda*, December 14, 1958, p. 2, and January 28, 1959, p. 1).

TABLE 21.—GASOLINE, FUEL OIL, AND DIESEL FUEL CONSUMPTION BY REGIONS, 1930 TO 1955, IN PERCENT OF TOTAL[1]

Region	1930	1940	1955
Gasoline:			
East (Urals–Siberia–Kazakhstan)	14.6	28.9	29.1
South (Ukraine–Caucasus–Central Asia)	31.4	33.1	34.1
Center (European R.S.F.S.R.)	54.0	38.0	36.8
Total (million metric tons)	0.5	3.0	15.0
Fuel oil:			
East (Urals–Siberia–Kazakhstan)	2.4	9.9	23.2
South (Ukraine–Caucasus–Central Asia)	42.4	47.0	37.4
Center (European R.S.F.S.R.)	55.2	43.1	39.4
Total (million metric tons)	7.0	9.0	17.0
Diesel fuel:			
East (Urals–Siberia–Kazakhstan)			38.1
South (Ukraine–Caucasus–Central Asia)			30.1
Center (European R.S.F.S.R.)			31.8
Total (million metric tons)			12.0

[1] Source: Gasoline and fuel oil data from *Neftyanaya promyshlennost' SSSR*, p. 283; Diesel fuel data from N. M. Mikhailov, "Soviet Crude Oil and Refined Products Supplies in 1956 and Plans for 1957," *Neftyanoye khozyaystvo*, No. 1 (1957), pp. 20–21.

oil from the Volga–Urals area to Baku for refining.[28]

Although the regional categories in tables 19 and 20 are not identical, it readily can be seen from a comparison of the two tables that, in spite of the absolute decline in crude oil output in the Caucasus and the preponderant rise in crude production in the Volga–Urals area, the Caucasus still produce more oil products than they can consume, and the Center, the Northwest, Central Asia, Siberia, and the Far East are deficient. Tables 21 and 22 give a rough idea of the distribution of consumption of leading petroleum products.

Most of the fuel oil is produced by the Kuibyshev and Ufa refineries from local high-sulphur crudes, and it is shipped from there to the west, south, and east. In 1956, about three million tons had to be shipped to the Caucasus, but construction of the Stavropol'-Grozny gas pipeline, the greater use of gas at Baku, and the conversion of railroads in Transcaucasia to electric and Diesel traction should allow for the elimination of the use of Volga–Urals fuel oil in the Caucasus within the next two or three years. Moreover, the conversion of Ukrainian oil-burning locomotives to coal should help to limit fuel oil consumption largely to the Volga–Urals area, where the bulk of it is produced.[29] Along with the general scheme, so far as it is possible to utilize the fuel where it is produced, it is planned to shift all thermal power stations, existing and projected, in Tataria from solid fuel to oil.[30]

The most significant point revealed by Table 22 is that most of the production of kerosene is in the Transcaucasian and Volga regions, while most of the consumption is in central European Russia, the Ukraine, and Siberia. European U.S.S.R. is supplied from the Volga–Urals, and it also received 100,000 tons from Grozny in 1956; the Siberian deficit in 1956 was covered by shipments of 550,000 tons by rail from Baku and Krasnovodsk. It has been urged that tractor kerosene production be increased at the Bashkir and Omsk refineries to take care of the Siberian market.[31]

The virgin lands of northern Kazakhstan used more than 2.5 million tons of motor fuels in 1956. To assure a better supply system, it has been urged that two refined-products pipelines be built from Kurgan to Kaibagar, a major distributing station on the South Siberian Railroad just east of Kushmurun, one for gasoline, the other for Diesel fuel. Apparently now this proposal has been superseded by the proposed Chelyabinsk–Atbasar products pipeline, which has been scheduled for construction in the seven-year plan.

In view of fuel shortages in European Russia, the Urals, and Central Asia, refineries in

[28] The Baku crudes, with their paraffin bases, are best used to produce only high-grade lubricating oils and high octane gasolines for all parts of the country; consequently, there is a shortage of fuel oil production in the Caucasus. The reversal of previously established flow of oil, from Baku across the Caspian and up the Volga, can be detected from tables on sea movements of petroleum products by Union Republics, which recently have been published by the Soviets. These show that from 1950 to 1955, shipments from the R.S.F.S.R. (Astrakhan) increased from 3.1 to 7.8 million metric tons, and arrivals in Azerbaidzhan (Baku) increased from 0.03 to 3.1 million tons (*Transport i svyaz' SSSR* [Moscow, 1957], p. 107).

[29] *Neftyanoye khozyaystvo*, No. 1 (1957), p. 21.

[30] *Pravda*, December 14, 1958, p. 2.

[31] *Neftyanoye khozyaystvo*, No. 1 (1957), p. 21.

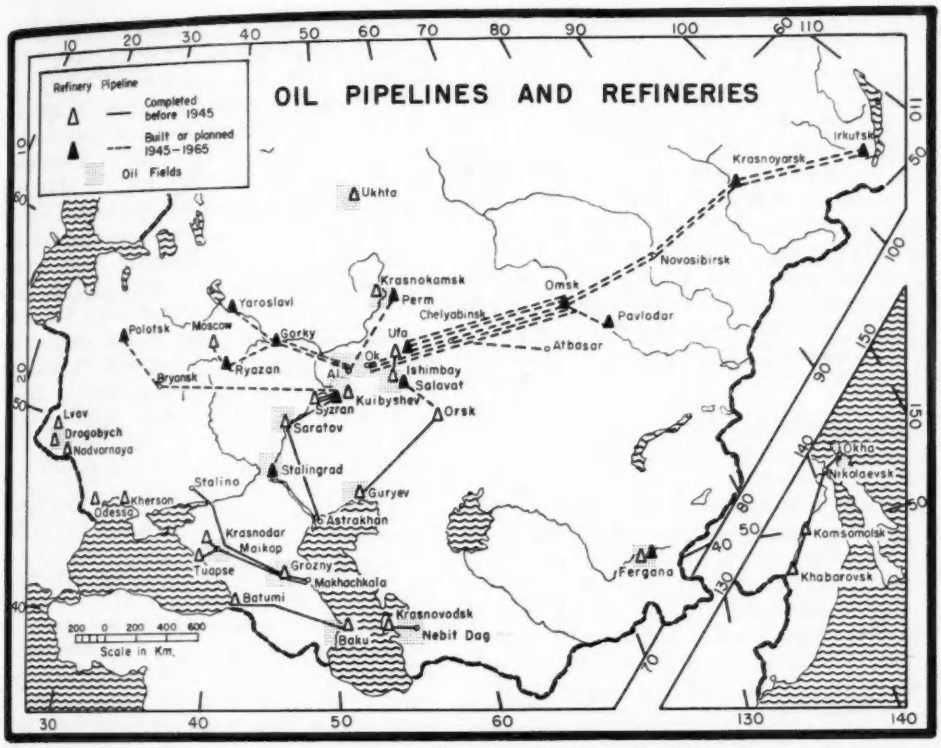

FIG. 11. Oil pipelines and refineries in the U.S.S.R., 1945–65 compared with 1945. Al = Almetyevsk; Ok = Oktyabrsky (production center of Tuimazy field). Mention has been made in the Soviet press of some refineries that are not shown on this map, but no specific locations have been given.
Sources: *Neftyanaya promyshlennost' SSSR* (Moscow, 1958), pp. 305–11; V. A. Pritula, *Transport nefti i gaza* (Moscow, 1948), p. 72; and *Izvestia*, February 15, 1959.

these areas should do only straight-run distilling to produce the maximum amount of fuel oil. On the other hand, in areas remote from oil and gas deposits, which have their own cheap coal, such as Siberia and Kazakhstan, greater use should be made of cracking to recover larger percentages of light fractions and thereby satisfy needs for petroleum products with a minimum of crude oil. The needs for fuel in Siberia, Kazakhstan, and the Far East can continue to be met by local coal, and thereby long-distance transport of oil products can be held to a minimum.

TABLE 22.—CONSUMPTION AND PRODUCTION OF KEROSENE FOR TRACTORS, BY REGIONS, IN MILLION TONS (1956)[1]

Region	Consumption	Production	+ Surplus − Deficit
Transcaucasia	0.06	0.64	+ 0.58
North Caucasus	0.4	1.2	+ 0.8
Volga	0.3	1.3	+ 1.0
Siberia	0.66	0.11	− 0.55
European Center and Ukraine	1.1	0.3	− 0.8

[1] Source: N. M. Mikhailov, "Soviet Crude Oil and Refined Products Supplies in 1956 and Plans for 1957," *Neftyanoye khozyaystvo*, 1957, pp. 21–22.

The great shift of crude oil production to the Volga–Urals area has brought about a radical change in the flow pattern of oil and has necessitated a change in the mode of transport. No longer is the Caspian–Volga water route the main line of oil movement; the big movement of oil in the future will be by pipeline from the Volga–Urals fields to the east, west, and northwest (Fig. 11). In 1958, pipe moved 40 percent of the total crude and refined tonnage, as compared to less than 12 percent before World War II. In comparison, the 1955 figures for the U.S.A. were approxi-

TABLE 23.—MODES OF SOVIET OIL TRANSPORT, IN PERCENT OF TOTAL OIL PRODUCTS SHIPPED, 1913 TO 1955[1]

Transport	1913	1940	1950	1955
By water	63.1	44.4	30.2	22.4
Sea movements	35.1	29.0	16.6	13.9
River and canal	28.0	15.4	13.6	8.5
By rail	34.5	44.4	50.8	46.5
By pipe	2.4	11.1	19.0	31.1
Crude	0.0	0.4	15.8	27.3
Refined products	2.4	1.7	3.2	3.8
Approximate total shipments (million metric tons)	17	67	85	165

[1] Source: *Neftyanaya promyshlennost' SSSR*, p. 284.

mately: transport of domestic oil by water, 15 percent; by rail and truck, 2 percent; and by pipeline, 83 percent.[32]

During the seven years 1959–65, total length of pipelines in the U.S.S.R. is to be nearly tripled and movement of fluids by pipe is to increase 460 percent. This means a construction of more than 30,000 kilometers of pipeline, about half of which are to be trunk lines. At the end of 1958, the total length of oil pipelines in the U.S.S.R. was approximately 15,800 kilometers, which compared to about 320,000 kilometers in the U.S.A.[33]

CONSUMPTION OF NATURAL GAS

The main natural gas deposits already have been listed, and Figure 7 shows the main centers of gas production at the present time and the projected production for 1965, some of which will occur in very recently discovered deposits. Table 25 shows the expected gas consumption in the U.S.S.R. by sectors of the economy in 1965, and, for comparison, Table 26 shows sales of natural gas in the U.S.A. in 1956 by major consumer groups. It appears that the Soviets intend to use a considerably higher percentage of their gas for power generation and considerably less for domestic purposes than is the case in the United States.

Gas field development is dependent entirely on the construction of pipelines. At the beginning of 1958, there was a total of 9,500 kilometers of gas pipelines in the U.S.S.R., and during 1958 approximately 30 billion cubic meters of gas were transported.[34] During 1959–65, 40 main pipelines totaling 26,000 kilometers are to be built; together with branch lines and with the oil pipelines to be built, this means a total of over 60,000 kilometers of pipe to be laid in seven years, or approximately 3 kilometers every working hour.[35]

Since natural gas is to become one of the basic fuels in industry and thermoelectric plants, pipelines will run generally from the main producing fields to areas of high industrial and population concentrations, and particularly to those areas which lack a source of good, cheap coal. Thus, pipelines have been and are being laid from the North Caucasus fields, Saratov, and the Western Ukraine to the Central Industrial Region.[36] The industries of the fuel-deficient Urals are to be

[32] Percentages were computed from data in *Minerals Yearbook 1956*, Vol. II, *Fuels*, pp. 354 and 357, showing receipts of crude petroleum at refineries in the United States by mode of transport, and adjusted to eliminate foreign shipments and to allow for differences in shipments of refined products.

[33] *Izvestia*, February 15, 1959. As of the end of 1956, pipelines in operation totaled 11,600 kilometers and included 31 long-distance lines, of which 25 were crude lines totaling 7,600 kilometers, and 6 were refined lines totaling 3,900 kilometers. The breakdown by diameters was as is shown in Table 24. Construction of 8-inch lines began in 1906, 10-inch in 1928, 12-inch in 1932, 14-inch in 1947, 20-inch in 1949, and 28-inch in 1957, which means that the older lines of the Caucasus are of small diameter, while the new lines of the Urals–Volga area are of larger diameter. In 1956, the three pre-revolutionary lines of the Caucasus handled only 3 percent of the total Soviet oil pipeline traffic.

[34] *Sovetskaya Rossiya*, July 8, 1958, p. 2.

[35] G. Goryachenkov, "Gas Is Being Supplied to the Country on a Gigantic Scale," *Promyshlenno-ekonomicheskaya gazeta*, September 7, 1958, p. 2. This tempo of construction is not so fantastic as it might at first sound; Canada was scheduled to build 40,000 kilometers of pipeline during the period 1956–60.

[36] Moscow now uses 4 billion cubic meters of gas and 6 million tons of coal annually. By 1965 Moscow is to use over 13 billion cubic meters of gas and 700,000 tons of coal annually; this gas consumption is more than the production in the entire U.S.S.R. in 1956 (Yu. Bokserman and others, *Gazovyye Resursy SSSR* [Moscow, 1959], p. 14). In 1958, Moscow received approximately ten times the amount of gas from Stavropol' as during 1957 (*Pravda*, February 25, 1958, p. 3). A second section of the Stavropol'–Moscow pipeline already has been completed to Lugansk in the Donets Basin (*Sovetskaya Rossiya*, July 8, 1958, p. 2). By 1965, shipment of coal to Moscow virtually should be eliminated and the production of the costly lignite of the Moscow Basin greatly reduced. It is hoped that within a few years Moscow fuel can be supplied 90 percent by gas and less than 8 percent by coal.

TABLE 24.—U.S.S.R. OIL PIPELINES BY DIAMETERS (1956)[1]

Diameter (inches)	Total length in kilometers	Percent of total
8	1100	9.6
10	1800	15.6
12	2800	24.4
14	2000	17.4
20	3800	33.0
Total	11,500	100.0

[1] Source: *Neftyanaya promyshlennost' SSSR*, p. 307.

supplied by gas pipelines from four different areas: the Central Asian fields, the Volga Valley fields, the Komi A.S.S.R., and Berezovo, along the lower Ob River.[37] Other fuel-deficient areas to be served by natural gas are the Leningrad area and the Baltic Republics; these areas are to receive gas from the fields of the North Caucasus and the Ukraine. Extensive use of gas in the North Caucasus and the Transcaucasus will alleviate long hauls of coal into those areas and will replace about 2.5 million tons of fuel oil per annum from the Volga–Urals. In the Transcaucasus, the gas line from the rich Karadag deposits to Kirovabad, Akstava, and Tbilisi, with a branch line from Akstafa to Yerevan, has been completed.[38] This will help greatly to solve the fuel problems in Transcaucasia, and particularly in Armenia, which has absolutely no fuel base of its own.

The newly discovered Bukhara gas deposits will supply gas to all the larger cities along the northern slopes of the Tien Shan. By 1965, the share of natural gas in the fuel balance of Uzbekistan is to rise to 60 percent, from 3.3 percent in 1958. This increased supply of natural gas will allow the area to abandon the use of Karaganda coal and will supply the fuel for several large new power stations. By 1975 the Bukhara production is scheduled to be between 55 and 60 billion cubic meters annually.[39]

In 1958, apartments housing more than 15 million people in 150 different cities were supplied with gas; this represented about 15 percent of the urban population of the country. From 1959 to 1965, gas is to be supplied to 50 million people in 500 cities, or roughly half of the urban population.[40] Underground storage depots are being developed near large cities by forcing gas into porous rock or underground water horizons to store gas for peak winter use; and in areas remote from pipeline services, the supplying of apartments with liquid gas in cylinders is being developed.

TABLE 25.—EXPECTED 1965 GAS CONSUMPTION IN THE U.S.S.R. BY SECTORS OF THE ECONOMY[1]

Sector of economy	Billion cubic meters	Percent of total
Technological needs of industry	60.0	40.0
Steel industry	26.7	17.9
Cement industry	8.4	5.6
Machine building industries	12.0	8.0
Other industries	12.9	8.5
Power generating needs	56.0	37.3
Residential uses	14.0	9.3
Chemical raw materials	8.5	5.7
Pipeline and gas field needs	11.5	7.7
Total	150.0	100.0

[1] Source: Yu. Bokserman and others, "Tasks of Development of the Gas Industry," *Planovoye khozyaystvo*, December, 1958, p. 33.

[37] By 1963, as much as 20 billion cubic meters of gas is supposed to flow annually from Central Asia to the Urals through lines running 2,100 kilometers from Bukhara to Chelyabinsk and 2,300 kilometers to Sverdlovsk. By 1965, the Urals are to use more than 25 billion cubic meters of gas annually, which will reduce the need for long-haul power coal by more than one-half (*Pravda*, January 28, 1959, p. 1).

THE PETROCHEMICAL INDUSTRIES

During the seven-year plan the chemical industry is to develop on an entirely new basis, that is, using natural gas and gas from oil refineries. Eighty percent of all organic chemicals produced in the U.S.A. use oil and

TABLE 26.—SALES OF NATURAL GAS IN THE U.S.A. IN 1956 BY MAJOR CONSUMER GROUPS[1]

Consumer group	Billion cubic meters	Percent of total
Smelters, mines, and manufacturers	123.4	40.3
Gas and electric power plants	35.4	11.6
Space heating and cooking	87.0	28.5
Oil company fuel	60.0	19.6
Total	305.8	100.0

[1] Source: *Minerals Yearbook*, Vol. II, *Fuels* (1956), p. 9.

[38] *Soviet Geography*, March, 1960, p. 78.
[39] *Izvestia*, December 24, 1958, p. 3.
[40] Yu. Bokserman and others, *Gazovyye Resursy SSSR*, p. 13.

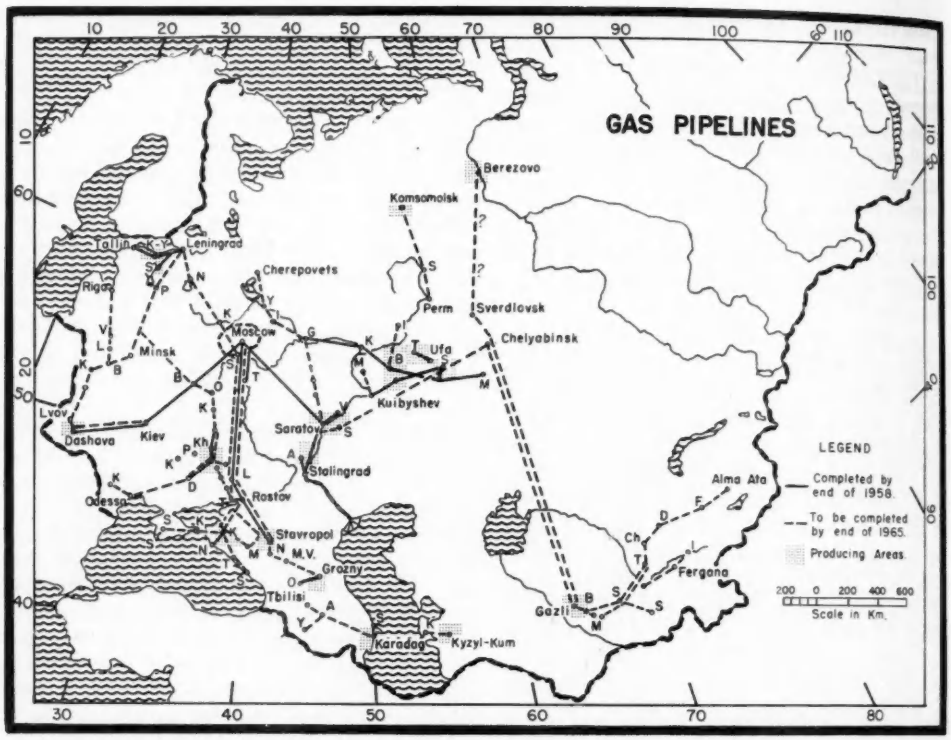

FIG. 12. Gas pipelines in the U.S.S.R., 1965 compared with 1958. Sources of information: *Promyshlennoekonomicheskaya gazeta*, September 7, 1958, p. 2; Yu. Bokserman and others, *Gazovyye Resursy SSSR* (Moscow, 1959), p. 9; and other scattered sources. One pipeline that does not appear on the map is the proposed line from Tas-Tumus to Yakutsk. Bokserman shows the Gazli-to-Sverdlovsk-and-Chelyabinsk pipelines as running west of the Aral Sea.

gas as raw materials.[41] If the Soviets intend to emulate this, and it is assumed that they do, then one can envision throughout the Soviet Union during the next few years a blossoming of the whole range of petrochemical industries associated with the expansion of the oil and gas industries. The total chemical output is to nearly triple, artificial fiber production to increase four times, and plastics and resins to increase seven times.[42]

It can be assumed that petrochemical plants will be built in all major producing and consuming areas, but particularly in the eastern Ukraine and in the Central Industrial Region where chemical raw materials from coal coking and metallurgical industries are being augmented by large quantities of gas piped in from the North Caucasian fields, from fields in the eastern and western Ukraine, from Saratov, and from the Volga–Urals fields. Other important industrial areas that can be expected to experience considerable developments in the chemical industries are the Urals, the Kuznetsk Basin, and the Leningrad area. Some of the outstanding projects to be built in outlying areas during the seven-year period have been mentioned individually in the Soviet press, and they are repeated here. Mention has been made of the Sumgait Synthetic Alcohol Plant in Azerbaidzhan; this probably is the largest operating synthetic plant in the country using petroleum gas. The chemical industries in Armenia are to be expanded greatly by utilizing the natural gas brought in by pipeline from Karadag.[43] In a few years,

[41] *World Petroleum*, January, 1959, p. 72.
[42] *Pravda*, January 28, 1959, p. 1.
[43] *Pravda*, November 26, 1957, p. 1.

Barnaul will have one of the largest artificial and synthetic fiber combines based on gas.[44] Work has begun on extensive construction of chemical industries in Uzbekistan based on Bukhara gas; these industries will turn out artificial silk and wool, nitrogen fertilizers, and plastics.[45] A large chemical industry is to be built in Bashkiria.[46]

The development of petrochemical industries will enhance agriculture in two ways. It will release annually several million tons of potatoes, grain, and sugar beets to help meet the food needs of the nation, and it will provide an enlarged base for the expanded production of sulfuric acid for superphosphate production and of ammonia for the production of nitrogen fertilizers. With adequate application of commercial fertilizers, it is envisioned that a great upsurge in agricultural productivity will take place.

SOVIET EXPORTS AND IMPORTS OF OIL

During the last decade Soviet exports of oil and oil products have risen by more than 40 percent per year, from a total of 1.1 million metric tons in 1950 to 25 million metric tons in 1959, with nearly as much going to noncommunist countries as to other countries of the Communist Bloc.[47] In general, exports to communist countries are mainly crude and to noncommunist countries mainly refined. The biggest customers in the Sino-Soviet Bloc are: China, mainly refined; Czechoslovakia, mainly crude; Poland, half refined, half crude; East Germany, all crude; Hungary, all crude; and Bulgaria, all crude. Part of the crude export to East Germany is returned to the Soviet Union in refined form. This round-trip shipment probably will cease when a planned refinery is completed at Polotsk in Belorussia. The biggest customers in the noncommunist world are: Egypt, mainly refined; and Finland and West Germany, all refined.[48] During 1959–60, the Gulf and Shell oil companies were forced to cut exports to Finland by three and one-third million barrels due to Russian penetration into that market.[49]

[44] *Pravda*, January 3, 1959, p. 4.
[45] *Izvestia*, December 24, 1958, p. 3.
[46] *Pravda*, January 28, 1959, p. 1.
[47] *Soviet Geography*, April, 1960, p. 85.
[48] *Vneshnyaya torgovlya Soyuza SSR za 1957 god* (Moscow: Vneshtorgizdat, 1958).
[49] *World Petroleum*, January, 1959, p. 68.

TABLE 27.—SOVIET EXPORTS OF OIL (1957), IN MILLIONS OF METRIC TONS[1]

Customer	Total	Crude	Refined
Communist Bloc	7.4	4.6	2.8
China	1.8	0.38	1.4
Czechoslovakia	1.3	1.2	0.10
Poland	1.3	0.63	0.70
East Germany	1.05	1.05	
Hungary	0.92	0.92	
Bulgaria	0.38		0.38
Noncommunist countries	6.3	1.3	5.0
Egypt	1.07	0.32	0.75
Finland	1.04		1.04
West Germany	0.75	-	0.75
France	0.55	0.32	0.23
Sweden	0.54		0.54
Italy	0.50	0.43	0.07
Yugoslavia	0.39	0.39	
Greece	0.30		0.30
Iceland	0.30		0.30
Total	13.7	5.9	7.8

[1] Source: *Vneshnyaya torgovlya Soyuza SSR za 1957 god* (Moscow: Vneshtorgizdat, 1958). Minor customers not shown.

The Soviet Union also imports some oil: from Austria and Albania, crude; and from Rumania and East Germany, refined. The July 12, 1955, agreement between the Soviet Union and Austria requires Austria to deliver 1.2 million tons of petroleum yearly in payment for property transferred to Austria by the Soviet Union when the Soviet armies evacuated the country.

According to the seven-year plan, a 2500-mile-long pipeline is to be constructed from the Kuybyshev fields on the Volga River to eastern and central Europe. The pipeline will divide at Mozyr, Belorussia, into a northern branch serving oil refineries at Plock, Poland, and Schwedt, East Germany, and a southern branch supplying refineries in Hungary and Czechoslovakia.[50]

TABLE 28.—SOVIET IMPORTS OF OIL (1957), IN MILLIONS OF METRIC TONS[1]

Supplier country	Total	Crude	Refined
Austria	1.1	1.1	
Albania	0.21	0.21	
East Germany	0.21		0.21
Rumania	2.6		2.6
Total	4.27	1.33	2.94

[1] Source: Same as Table 27. Minor suppliers not shown.

[50] *Soviet Geography*, June, 1960, p. 76.

Besides the trade in oil products, the Soviet Union is selling oil equipment and offering technical assistance to those countries who want it. The United Arab Republic is getting refining technical assistance from the Soviet Union and East Germany,[51] and Argentina has been buying oil-field equipment from the U.S.S.R.[52]

As has been the case recently in certain other sectors of the economy, it appears that the Soviet Union has reached a level of petroleum production that allows for some surplus to be exported. In view of the large reserves of oil in the Soviet Union and the projected expansion of its annual production, sometime after 1972, to three or four times the present production in the United States, it can be assumed that the Soviets definitely plan to enter the world petroleum market on a large scale. Perhaps the growing markets of China and other satellite countries will absorb the bulk of this Soviet export, but the United States, Venezuela, and the Middle East can look forward to a time when the world petroleum market will have to be adjusted to consider the new Soviet supplier, and under these conditions it is doubtful whether the present world price structure, based on prices at the Gulf Coast of the United States, can be maintained.

[51] *World Petroleum*, January, 1959, p. 68.
[52] *World Petroleum*, February, 1959, p. 88.

APPENDIX—SUMMARY OF DEVELOPMENT OF OIL PIPELINES IN U.S.S.R.[1]

Name	Date built	Length	Diameter	Tons per year	Use
Pre-Revolution:					
Baku–Batumi	1896–1906	833 km.	8 in.	900,000	Originally kerosene to Batumi for export; converted to crude in 1930
Tukha–Krasnodar	1910–11	102 km.	8 in.	900,000	Maikop crude to Krasnodar refinery
Makhachkala–Grozny	1913–14	162 km.	8 in.	700,000	Grozny crude to Makhachkala kerosene plant
Total: Three 8-inch pipelines totaling 1,147 km. and 2,500,000 tons per year					
Inter-War Period:					
Grozny–Tuapse	1926–28	644 km.	10 in.	1,600,000	Grozny crude to new Tuapse refinery
Baku–Batumi (2nd line)	1927–30	823 km.	10 in.	1,600,000	Baku crude to new Batumi refinery
Armavir–Trudovaya	1931–32	455 km.	12 in.	1,500,000	Originally Grozny refined products to Donets Basin
(But, as it soon became evident that Grozny crude output was declining and Maikop output was rising, the following changes were made: (1) Grozny–Armavir section of Grozny–Tuapse line was connected to Armavir–Trudovaya line to take Grozny kerosene to Ukraine over an 880-km. line. (2) Maikop–Tuapse section of original Grozny–Tuapse line was used to take Maikop crude to Tuapse refinery over a 58-km. line.)					
Guryev–Orsk	1932–36	709 km.	12 in.	1,200,000	Originally Baku crude from Guryev terminal to Orsk refinery
(As Emba crude output increased, the pipeline was used to carry Emba crude to the Orsk refinery. In this connection, a 118-km., 8-inch line was laid from Koschagyl section of the Emba field to the main line, in 1934.)					
Makhachkala–Grozny (2nd line)	1935–36	155 km.	12 in.	1,500,000	Apparently to take Baku crude from Makhachkala terminal to Grozny refinery, because of sharp drop in Grozny output after 1933

Name	Date built	Length	Diameter	Tons per year	Use
Ishimbay–Ufa	1936	168 km.	12 in.	1,200,000	Originally to carry Ishimbay crude to Ufa refineries

(In 1945, as Ishimbay refinery was expanded and Tuimazy output began to rise, flow was reversed, carrying Tuimazy crude from Ufa to Ishimbay refinery. In 1957, flow was reversed once again, taking refined products from Ishimbay refinery to Ufa. Ishimbay now is being supplied by a new pipeline from Tuimazy by-passing Ufa [Subkhankulovo–Shkapovo–Ishimbay line].)

Wartime Construction:

Zolny–Syzran	1941	136 km.	10 in.		Crude from newly discovered field in Samara Bend to Syzran refinery

(Later a second parallel line [100 km., 10 inch] was added from Yablonovy to Syzran.)

Astrakhan–Saratov	1943–44	655 km.	10 in.		

(This line was made with pipe of the dismantled second Baku–Batumi line. From 1944 to 1956, the new line was used to carry Baku refined products from the Astrakhan terminal to Saratov. After 1956, in connection with the rising crude output in the Volga–Urals area, the flow was reversed, carrying crude southward from the Kuibyshev area, which had in the meantime been connected by pipe with Saratov. A 49-km. pipe links the Kuibyshev–Saratov pipe with the Saratov–Astrakhan pipe at Urbakh, junction of Saratov–Uralsk and Saratov–Astrakhan railroads.

All pipelines in the Northern Caucasus were put out of action in World War II, but were restored by the middle of 1944.)

Post-War Developments:

By the end of 1945, pipelines totaled 4,400 km., as compared with 4,100 km. at the end of 1940, but the volume of oil pumped was lower, 5.6 million tons, as compared with 7.9 million tons in 1940, because of a cut in production.

There was relatively little construction during the fourth five-year plan, 1946–50, total length rising from 4,400 km. in late 1945 to 5,400 km. in late 1950. But the utilization rate jumped sharply, as 15.3 million tons were piped through in 1950.

In the fifth five-year plan, 5,100 km. were added, which nearly doubled the length of the total pipeline system, to 10,400 km. in 1955. The longest line of the fifth five-year plan was the first Tuimazy–Omsk line, 1,332 km., 20 inches, which carried crude to the Omsk refinery, which was opened in 1955. Nearly as long was the Ufa–Omsk refined products line, which carried products from the Ufa refinery to the large oil-products consumption area of western Siberia.

The sixth five-year plan, 1956–60, which was later cancelled to be superseded by the new seven-year plan, called for 14,500 km. of new pipelines, with a total system of 25,000 km. by 1960. The sixth five-year plan included the following lines:

Tuimazy–Omsk, 2nd line	crude
Ufa–Omsk, 2nd line	refined products
Omsk–Novosibirsk	refined products
Omsk–Irkutsk	crude
Novosibirsk–Irkutsk	refined products
Almetyevsk, Tatar fields–Gorky	crude
Almetyevsk–Perm	crude
Gorky–Ryazan	crude
Ryazan–Moscow	crude
Gorky–Yaroslavl	crude
Ishimbay–Orsk	crude
Kuibyshev–Penza–Michurinsk–Bryansk–Polotsk	refined products

The reported completions by the end of 1958 were as follows:

Tuimazy–Omsk, 2nd line	crude
Ufa–Omsk, 2nd line	refined
Almetyevsk–Gorky	crude
Almetyevsk–Perm	crude

The Omsk–Novosibirsk gasoline line opened in February, 1959.

Among the pipelines listed to be built during the seven-year plan are the following:

Almetyevsk–Gorky, 2nd line		crude
Gorky–Ryazan	left over	crude
Gorky–Yaroslavl	from sixth	crude
Kuibyshev–Bryansk–Polotsk	five-year	refined
Ishimbay–Orsk	plan	crude
Tuimazy–Omsk, 3rd line		crude
Omsk–Pavlodar		crude
Chelyabinsk–Atbasar		refined

[1] Sources: Same as Figure 11.

LETTERS AND COMMENTS ON *ANNALS* TOPICS

MAP SYMBOLS: "THE CURVE OF THE GREY SPECTRUM"—AN ANSWER

In the Letters and Comments section of the December 1959 *Annals*, Arthur H. Robinson criticized my findings on equal-appearing intervals for printed screens as reported in the *Annals* for June 1958, pp. 132–39. He states three broad objections:

1. "I think considerable question can be raised concerning his procedure, and hence some of his conclusions."
2. ". . . I do not believe his testing is adequate for its stated purpose, viz., the selection of value screens for map use."
3. ". . . I believe the most significant cartographic aspect of the test results is their variability. These were not reported in the *Annals* article."

I will discuss these remarks in the order in which they appear in Robinson's article and assume that you will have my original article and his criticism before you while reading this.

QUESTIONED CONCLUSIONS

The first of two conclusions questioned was my statement that Fechner's Law is not applicable to even-appearing steps for printed screens. There are three basic errors in Robinson's argument on this point. First, he errs in equating reflectance with stimulus. It is false to say that value sensation *must* be equated with reflectance determinations. Reflectance is but one way of assigning a number to a stimulus. For a flat tone it may be the only way, but, for screens of sufficient coarseness so that the pattern elements are distinguishable, there is another way of giving number identification to the stimulus. It is the percent of area covered by the pattern. Most map makers will not have available the equipment necessary to measure the reflectance of a given screen, but it is simple to determine the percent of area in ink. Further, because of interior inductance or "spreading effect,"[1] reflectance is not a good measure of stimulus in this case. The absolute reflectance of the ink and the paper is of little importance as long as the contrast between them is strong. This is shown by the results of my black screen and colored screen tests. The results of each were essentially the same in spite of differences in absolute reflectance except for the one color, yellow, where the contrast between it and the background paper was not strong. It would be possible to make further tests to determine the practical limits of contrast that could be tolerated. However, in map design we don't want to work in the area of limits; this part of the problem is best left to psychophysics.

Second, Robinson errs in saying that I designated solid black as 0 and white paper as 100 reflectance. I have not. As explained above, I deliberately avoided reflectance as a measure of stimulus. The solid black and the white paper are two end points of a visual scale and can be assigned any arbitrary numbers. It was the purpose of these tests to find the screens that would subdivide this scale into equal-appearing steps. In any case, it is immaterial, within very wide limits, what the reflectance of the ink or the paper is. The eye is very adaptable, and a surface that reflects as little as 50 percent of the light will appear white as long as it is non-selective for color and is the brightest surface in the field of view.[2] In printing it is impossible to get an absolute black, but for practical design problems this is unimportant. Robinson fails to keep in mind that I was setting up an empirical scale. I was dealing with visual evaluations, not mechanical ones; with printed screens, not flat tones; with white paper on which maps are printed and the full color available from an ink, not theoretical "white" and "black."

Robinson's third error points up one of my reasons for using percent of ink, a measure easily made by any map maker, for assigning a number to a screen. If Robinson had had available equipment for measuring reflectance of the printed screens (I sent him copies of the screens and tests at the beginning of the project in the spring of 1954), he would have found that linear conversion from reflectance to area of ink doesn't work, and that the por-

[1] Ralph M. Evans, *An Introduction to Color* (New York, 1948), p. 181.

[2] *Ibid.*, p. 124.

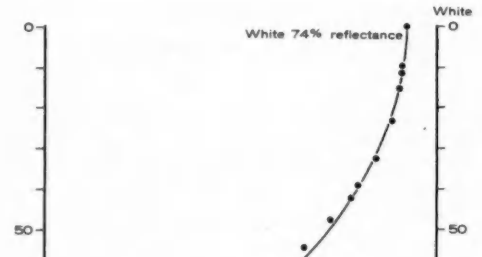

FIG. 1. Curve of the grey spectrum based on measured reflectance.

tion of his argument based on such linear conversion is meaningless.

Here it is interesting to note that the Weber–Fechner scale used by Robinson for his linear conversion from reflectance to percent of ink is not, as some readers might have been led to think, the scale recommended by Loyd Jones for use in selecting even-appearing visual steps. Since the publication, which was Robinson's source, is difficult to obtain, I will quote it at some length:

> Having found values of 6.2 per cent and 70.4 per cent reflectance for the black and white areas respectively, and using these as end members of the series, we computed Table 1.

	1 *Weber–Fechner*	2 *Munsell Color Chart*	3 *Munsell Value Scale*	5 *Recommended Scale*
Black	6.2	6.2	6.2	6.2
	10.0	13.0	10.2	10.2
	16.4	21.5	20.3	20.3
	26.6	35.0	32.0	35.0
	43.2	51.0	48.5	55.0
White	70.4	70.4	70.4	70.4

Table 1—Reflectances according to various scales

> In the first column are the reflectances that should give equal sensory steps according to the accepted form of the Weber-Fechner relationship. [*These are the values Robinson used.*] In the second column are the values as derived from the Munsell color chart data. (By the way, these data were determined with great care and in my [Jones's] personal opinion give a more uniformly stepped scale than the Weber-Fechner data.) In the third column are the values of reflectances as derived from the Munsell standard value scale. I regard the values shown in this column as the most reliable available.
>
> . . . . . .
>
> Thus far we have based all of our reasoning on average reflectances, and I feel very confident that if we were dealing with areas of uniform reflectances—that is, not line structure but grays printed solidly without structure—a scale printed according to the data in the [Munsell standard value scale] of the table would meet all the requirements of equal sensory steps between adjacent members. When, however, we are dealing with a scale in which the end members are of uniform reflectance and the four medial members all have a structure that is the same in the four cases, there is little doubt in my own mind that the magnitude of the sensory or perceptual step between the white area and the adjacent ruled area having an average reflectance of 48.5 per cent is considerably greater than that between the same white area and an adjacent uniformly gray (non-structured) area having a reflectance of 48.5 per cent. In other words, the very presence of the structure is of itself a factor that modifies profoundly the magnitude of our estimate of the perceptual or sensory difference between two areas. I feel, therefore, that in using a scale in which the four medial members have a parallel line structure and the two end members no line structure, we are warranted in changing the relationship as shown in the [Munsell standard value scale] of Table 1 to that as shown in the [recommended scale]. . . . In the fifth column of the table I have set down a suggestion, which in my opinion would come very close to giving you equal sensory steps between the adjacent members of this type of series.[3]

Examination of the tables of Loyd Jones shows that his recommended scale has moved away from the Weber–Fechner scale and in the direction of my curve of the grey spectrum for printed screens. The values of this recommended scale are based on intelligent guess. My study aimed to find a scale based on experimental data. I include the following figures for your comparison.

1. Reflectance scale recommended by Loyd Jones (column 5): Black 6.2%, 10.2, 20.3, 35.0, 55.0, White 70.4% reflectance.

2. Linear conversion of recommended scale, 1, to percent of ink: Black 100%, 82.5, 69.4, 47.7, 17.4, White 0.0% of area in ink.

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[3] John K. Wright, Loyd A. Jones, L. Stone, and T. W. Birch, *Notes on Statistical Mapping: With Special Reference to the Mapping of Population Phenomena* (American Geographical Society, 1938), pp. 21–23.

3. Actual percent of ink needed to fit the recommended scale, 1, as determined by reflectance measurements of my screens: Black 100%, 95, 80, 55, 25, White 0% of area in ink.

4. Percent of ink scale for even visual steps as determined by my experiments: Black 100%, 84, 59, 29, 7.8, White 0% of area in ink.

Line three is not strictly comparable to the Loyd Jones recomended scale since my black was 8 percent and my white 74 percent reflectance, but the great difference between lines two and three clearly shows that linear conversion from reflectance to percent of area covered by ink doesn't work. Fig. 1 is the curve of the grey spectrum based on measured reflectance instead of on the percent of ink scale. Again the line is curved showing that the Weber–Fechner law does not apply to equal visual steps between printed screens. The reflectance measurements were made by the Color Measurement Laboratory of the Massachusetts Institute of Technology. My findings are but a part of the accumulating evidence that shows the Weber–Fechner law is not applicable to category scales.[4]

The second conclusion questioned was the one that stated that the end points of a series didn't need to be black and white for the curve of the grey spectrum to be useful in selecting equal-appearing steps. Robinson states that this conclusion is too strong but gives no evidence to support his statement. Instead he argues about the position of the curve in relation to the percent of ink scale. Incidentally, the tests he refers to in Munsell, Sloan, and Godlove are *not* on the same subject as mine. Munsell deals with flat, patternless tones, while I dealt with printed screens.[5] Robinson claims that there is a built-in bias in my results because I have used a white background for the tests. In the Office of Naval Research report that Robinson has cited several times, I say, "As well as the kinds of symbols we are using, we need to say what kinds of maps we are working with. It is the printed map, such as an atlas page or planning map or an illustration in a text or report, that is used at normal reading distance and under normal conditions that we are most interested in and have the most use for. This work is concerned with this kind of map."[6] Since this kind of map is usually printed on white paper, I feel justified in using a white background for my tests. As to whether or not my conclusion is too strong, I cannot say. I reported the results of the tests. Only further testing, not Robinson's beliefs, can alter them.

ADEQUACY OF THE TESTING PROCEDURE

Robinson states that I have neither determined the sensitivity of the human eye to value change nor measured how people react to value symbols on maps, and I agree with him. I did neither, as these were not my aim. Robinson has used the word "value" in two separate ways. When he speaks of "value change" he is getting back to changes in reflectance, and is using the word in the very narrow sense given it by Munsell. When, in the same sentence, he speaks of "value symbols" on maps he means numerical value symbols, or what I call statistical symbols. This double use of a single word can be confusing to the unwary. Of course I would not attempt to test for the sensitivity of the eye, as such would be outside my competence and has already been done. As for testing the reaction to numerical value symbols on maps, I feel it would be unrewarding since each map is a distinctive visual display. Only for the simplest maps could testing of one be used as prediction for another. It does not logically follow that these are the only two ways of testing. My aim was to establish an empirical scale of even-appearing steps for printed screens. I was encouraged to work with this isolated symbol by this statement: "The reason that visual composition is so subjective and devoid of objective testing is probably, or at least partially, due to the assumption that, because of the infinite number of possibilities, any testing of isolated components would be of little actual worth. It seems likely, however, that a number of cartographic proce-

[4] S. S. Stevens, "On the Psychophysical Law," *Psychological Review*, Vol. 64 (1957), pp. 153–81, and S. S. Stevens, "Ratio Scales and Category Scales for a Dozen Perceptural Continua," *Journal of Experimental Psychology*, Vol. 54 (1957), pp. 377–411.

[5] A. E. O. Munsell, L. L. Sloan, and I. H. Godlove, "Neutral Value Scales: I. Munsell Neutral Value Scale," *Journal of the Optical Society of America*, Vol. 23 (1933), pp. 394–411.

[6] Robert L. Williams, *Statistical Symbols for Maps: Their Design and Relative Values* (Map Laboratory, Yale, 1956), p. 5.

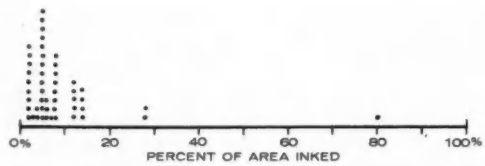

FIG. 2. Tones selected by the sixth grade children to fill value step 20 of a six-step scale from white (0) to black (100). Each dot represents one child's choice.

dures could be evaluated by testing."[7] All of the questions about illuminants, rigorous controls, cocktails, and the behavior of the children are irrelevant. The only pertinent question raised here is: Is the sample large enough? I believe that it is, but I admit that my belief is based on faith in the members of the Yale Psychology Department who assured me that such a sample would be large enough to give meaningful results. In using this scale of screen values for designing maps, it must be remembered that exact numerical judgments from screens are not to be expected. All we can expect is to approach more nearly the conditions where visual impression is the most accurate for the most people.

[7] Arthur H. Robinson, *The Look of Maps* (University of Wisconsin Press, 1952), p. 72.

VARIABILITY OF THE RESULTS

Robinson is right in saying that I should have included information on the variability of the results, but he would have been prudent not to attempt, with the limited data available to him, to show that the variability was great. Standard deviation, which he has used, is not a good measure of variability in this case. It has meaning only for results that are normal or near normal in their distribution. Under the conditions of my tests, many of the results will be skewed. As an example, take the Value Step 20 in Robinson's table giving standard deviations. It is obvious that the screens selected to fit this position on a white to black scale will be bunched at the lighter end of the scale, and there is less chance for variation from the average toward white than there is in the other direction from the average toward black. The standard deviation of step 20 is rightly computed as 11.6, but there is one extreme answer, 80, as shown in Fig. 2, that makes this so. If this one answer is dropped, the standard deviation becomes 5.7. If the next two extreme answers, 28, are dropped, the standard deviation be-

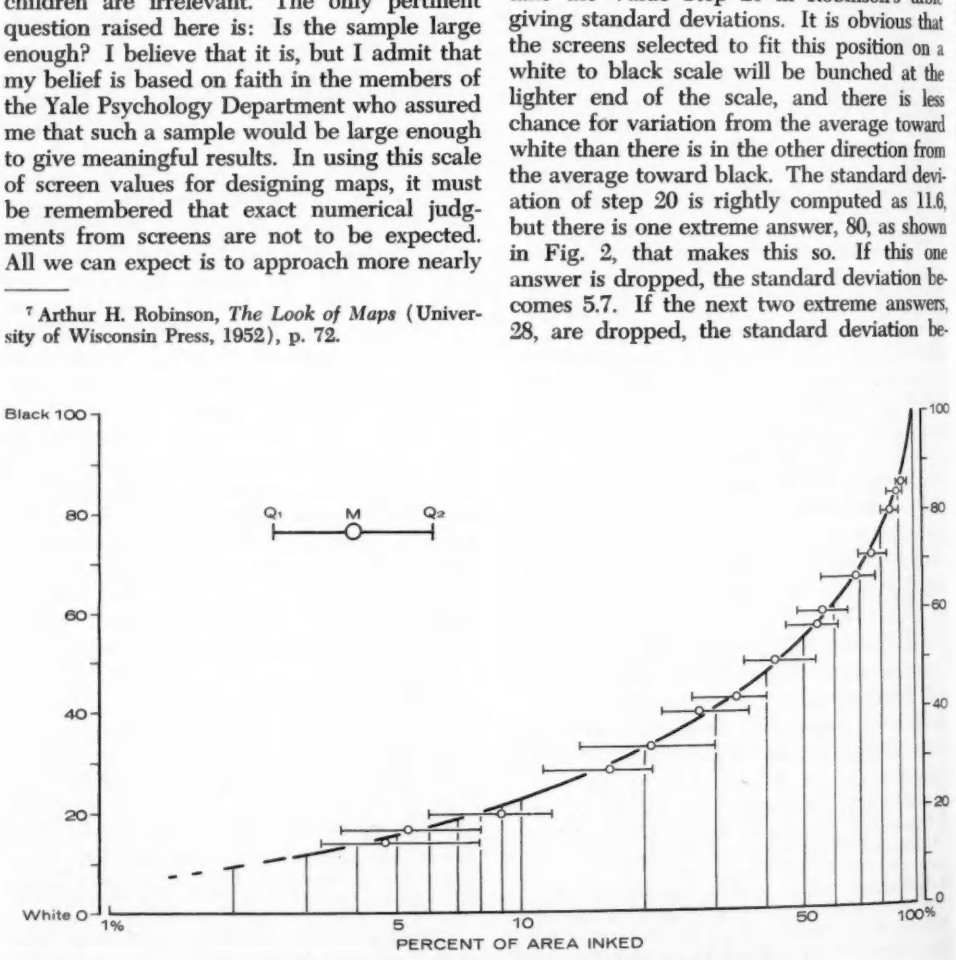

FIG. 3. The median and quartile points of the dot tone tests.

comes small indeed. Standard deviation is not applicable to skewed distributions. Not only has a poor measure of variability been used, but the values obtained have been plotted on the wrong axis of the graph. They should have been plotted along the percent-of-area-inked scale and not along the value scale.

I have used the median and the quartiles since these give equal weight to all answers without allowing the extreme ones to bias the results. The medians and the quartiles for the entire population of the dot screen tests are shown in Fig. 3. The variation of the answers is not as great as Robinson's figures suggest.

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THE GEOGRAPHY OF COMMUTING

Professor Dickinson, in his letter to the *Annals*, September 1960 (p. 296), raises at least five points, either directly or by implication, about my comment on his article on commuting. It seems relevant to take up merely two.

He says that "in Germany there is a remarkable consistency in the average area of the *Gemeinden* as between one *Land* and another," and that each *Gemeinde* measures about 10 sq. kms.; he says that therefore my comment on regional contrasts of size is "just not valid." One would hardly expect the average to vary much between one *Land* and another, there being so few *Länder*. In which case, are not the following figures striking, showing more than a 100 percent variation in the average area of *Gemeinden* in two *Länder*?

Land	Average area of *Gemeinden*, sq. km.[1]
Schleswig-Holstein	11.2
Niedersachsen	11.1
Nordrhein-Westfalen	14.3
Hessen	7.8
Rheinland-Pfalz	6.8
Baden-Württemberg	10.6
Bayern	9.9

If we assume for the moment that all the *Gemeinden* are circular, this represents a range in diameters from 3.1 kms. to 4.3 kms., which must surely have some influence upon the chances of any individual being recorded as a commuter.

Much more important is the fact that within the *Länder* there are even bigger variations in the size of the *Gemeinden*, as may be illustrated by the case of Schleswig-Holstein. The following are the figures for the rural *Kreise*:

Average area of *Gemeinden*, sq. kms.	Number of *Kreise*
7	1
8	2
9	3
10	2
11	2
13	3
14	2
25	1
51	1

Of the four urban *Gemeinden*, the smallest (Flensburg) is 35 sq. kms. and the largest (Lübeck) is 202 sq. kms. If we again assume that the *Gemeinden* are circular, Schleswig-Holstein contains a range of diameters from 3 kms. to 16 kms.

Reference to the relevant sources will show that within Belgium and the Netherlands there are equally large or bigger variations in the areal extent of the smallest administrative units.

In any case, to write in terms of averages is to miss the fundamental point which I tried to make, which is that one must be concerned with dispersions and probabilities. Professor Dickinson says, "It is really quite irrelevant and misleading to talk of the journey to work as based on a 'small sample'," because the material, "over large areas, deals with a substantial proportion and even an overwhelming majority of the workers." But each *Gemeinde*, or aggregation thereof, represents only a small

[1] *Source: Die Bevölkerung im Jahre 1958*, Statistisches Bundesamt, 1960.

sample from the total universe of observations. Even if the universe represents a normal distribution, any sample taken therefrom may be expected to deviate from the "norm." This problem would not be acute were all administrative units the same size and contained the same population. It is my submission that where there are marked differences in the areas of the administrative units—such as I have shown to exist in Germany — a strong bias is introduced into the figures which purport to represent commuting, causing an overestimate where the administrative units are small and *vice versa*.

It does not follow that the census returns cannot be used. For example, if the administrative boundaries have not changed, valid comparisons are possible between censuses. A realization of the limitations of the figures should enable us to select the appropriate methods of analysis.

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REVIEW ARTICLES

GRAVITY AND POTENTIAL MODELS IN ECONOMIC GEOGRAPHY

Publication reviewed:

Toward a Geography of Price: A Study in Geo-Econometrics, by William Warntz. Philadelphia: University of Pennsylvania Press, 1959. 104 pp., maps, graphs, tables, index, bibliography, 5⅛ × 8¼. $5.00.

In two recently published articles William Warntz of the American Geographical Society has written a *Novum Organum* for research in economic geography.[1] It consists of two parts: a framework within which various approaches to economic geography are given their proper position and roles; and an exposition of the basic approach upon which less fundamental approaches necessarily rest. This new charter for a *science* of geography is introduced with a historical perspective:

> The roots of geography are in antiquity. Geographers have always been interested in spatial distributions of a wide variety of phenomena and now after two millenia there are geographers who are especially concerned with the spatial arrangement of economic phenomena.[2]

It is then argued that there are really only two approaches to the study of economic geography, the *macroscopic* and the *microscopic*, but they are not equal:

> . . . macro analysis is aimed at developing concepts at a more meaningful level of abstraction so as to make possible the understanding of the whole economic system and to provide a conceptual framework into which to put the micro-descriptions.[3]

Warntz admits to a bias for the macroscopic approach because it is "in this macroscopic approach that the forging of a theory of human society can be greatly aided by finding regularities in the aggregate." Admittedly "this view is not easily come by and offends many observers" possibly because "the general objective is to establish one social science and to show that it and physical science are but mutually related isomorphic examples of one generalized logic."[4] It is in the further exposition of the details of the macroscopic method as now practiced that one begins to understand the nature of the offense taken by many observers to the new science.[5]

The remainder of this article will be concerned with a number of studies advocating and explicating both the investigation of spatial (i.e., geographical) regularities and the establishment of isomorphism between physical and social science. Such a review involves more than what are normally considered to be macro-analytic studies but it is a necessary

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[1] "Progress in Economic Geography," *New Viewpoints in Geography*, P. James, ed. (Twenty-Ninth Yearbook of the National Council for the Social Studies [Washington: 1959]), pp. 54–75. W. Warntz, "Geography at Mid-Twentieth Century," *World Politics*, Vol. 11 (April, 1959), pp. 442–54.

[2] Warntz, "Progress in Economic Geography," p. 54. In the article in *World Politics* a short history of the subject is epitomized around the names of Taylor, Barrows, Sauer, Leighly, Spate, *et al.* The part on Sauer is representative, viz.: "Having ruled out the rational interpretation of both physical environment and social phenomena, having questioned the validity of reasoning from any set of a priori principles, having denied to geographers the role of attempting to find any abstract relations, and having limited any one investigation to an extremely small part of the earth's surface, Sauer set a standard which in the main seems to have dominated American geography until quite recently. And, although Sauer has on several occasions announced publicly his regret at this turn of events in geography, the record of the past thirty years is indelibly written." Warntz, "Geography at Mid-Twentieth Century," pp. 445–46.

[3] Warntz, "Progress in Economic Geography," p. 55.

[4] Warntz, "Geography at Mid-Twentieth Century," pp. 450, 448–49; also, Warntz, "Progress in Economic Geography," pp. 57–59.

[5] It is no secret that the greatest offense is taken not by the "artistic and subjective geographers," but rather by other "quantitative geographers" who have difficulty in abstracting their data to the same levels as Warntz *et al.* The methodological distinction between macroscopic and microscopic is specifically in the size of the descriptive unit. A macroscopic geography would only refer to group or aggregate descriptive relations, i.e., the description not of individual phenomena but of wholes. Warntz describes this approach as "a means for raising the level of abstraction and for making use of the analysis of variables in order to measure the functional consistency and organic unity of a whole system which is greater than the sum of its parts." How one measures and arithmetically handles variables which cannot be summed as a whole and, therefore, cannot be analyzed (i.e., broken down into constituent parts) is never explained. Warntz, "Progress in Economic Geography," p. 58; also W. Warntz, "Contributions toward a Macro-economic Geography: A Review," *Geographical Review*, Vol. 47 (July, 1957), pp. 421–22; J. Q. Stewart and W. Warntz, "Macrogeography and Social Science," *Geographical Review*, Vol. 48 (April, 1958), p. 168.

procedure in order to achieve a proper perspective and context for criticism. William Warntz's *Toward a Geography of Price* is the most detailed monograph yet published using a fully macroscopic approach and will be considered first.[6] Secondly, a number of earlier studies concerned with statistical regularities and the use of equilibrium models will be compared with the Stewart/Warntz "potential" approach. Finally, the philosophic underpinnings of macroscopy as now practiced will be discussed.

I

Toward a Geography of Price contains several themes. The first theme is an *apologia* for the macroscopic approach, given the failure of traditional geography.[7]

> It is said that events happen at times and at places; and the nature of the event itself, its magnitude, the place, and the time of its occurrence constitute the circumstances of its reality. A drop of rain falls; a price is paid for a bushel of wheat. We have come arbitrarily to classify the former as a physical phenomenon and the latter as an economic phenomenon. Yet, both have in common in the reality of their occurrence the facts that they happen at a time and a place. The fact that human attitudes and dispositions are involved in the second phenomenon and not in the first does not mean that the second one does not have measurable physical dimensions.
>
> Early in the history of the social sciences there was a strong tendency to place complete emphasis upon the so-called human aspects of economic phenomena without regard to the physical dimensions of the data, save for those quantities relating to magnitude. Geographers collected, classified, and systematized their data in terms of spatial distribution; but they were not especially interested in economic activity, as such, cared little for economic theory, and certainly made little attempt to develop a theory of economic activity recognizing the significance of space and distance. Geographical description of (i.e., assigning location to) economic activity alone did not constitute spatial analysis of economic activity. This was the case and only now are the full dimensions of economic activity being reckoned with.

Warntz would insist that for studies in economic geography:

> Space is a continuum and all distances and directions in the area in which an economic system functions are interdependent; all phenomena share in common the fact that their economic attributes are areally distributed and vary geographically in intensity. A theory which includes the concept of the interdependent nature and the simultaneous determination of all economic attributes should also include a recognition of the interdependence of all distances and directions. The task is to account for the variations from place to place and to identify the universal persisting tendencies associated with the dimensions of the phenomena.
>
> Herein lies the essence of the economic geographer's contribution. His concern is in the areal differentiation of economic phenomena. His objective is to describe geographical patterns and to discover the causes and the consequences of these given areal distributions.

The above view of what economic geography was and what it could, or should, become, is the underlying motif of the book. Without this context much of what follows would seem narrow and deviate; with these assumptions the developed thesis becomes explicable. Nevertheless, these assertions are but a prelude and not the main theme. Further restrictions are made before the full monotone of the new social physics is made explicit:[8]

> The purpose of this study was to develop the theory of space potential and demonstrate its usefulness as a type of methodology in economic geography, i.e., to develop a dimensional analysis of economic activity using the primary concepts of mass, time, and space, factors which are included in the basic reality of all phenomena.
>
> The study was not expanded to consider all the possible refinements and improvements of more elegant mathematical or

[6] Warntz, *Toward a Geography of Price: A Study in Geo-Econometrics*, *op. cit.*

[7] The collation which follows is taken from the following pages: 13, 14, 22, 35, 41, 42, 100.

[8] The collation which follows is taken from the following pages: 35, 41, 47, 86, 90, 91, 98, 100, 101, 103.

statistical techniques nor does it include particular and specifically limited variables. No attempt was made to analyze the individual peculiarities of the commodities involved. Site factors, such as differing soil fertility, improvements made on the land (including irrigation facilities in some cases), climatic factors (including the time relationship advantages that may result from being able to produce in the "off season"), and the like were not taken into account. Neither was location theory developed; the location of production, populations, and incomes were assumed as given.

Warntz argues that:

> The limited number of variables, the universality of them, and the simple formula used are the merits of the study. More complex formulae and additional variables required to yield perfect correlation for each commodity would not be universal but peculiar and unique. For precisely these reasons greater significance can be attached to the values computed. Without doubt, experimentation with various exponents of distance and also time differences would produce "better" fits and would bring about a better approximation of reality but they would nevertheless be just that—improvements and refinements of the already outlined dimensional analysis.

What then is the main thesis? The thesis is the conclusion. Having removed all variables except the universal persisting tendencies associated with the dimensions of the phenomena, "the hypothesis of the study is stated . . . as a theory (a hypothesis partly verified by fact)."[9] Lifted above the specifics of this particular study—wheat, potatoes, onions, and strawberries—the thesis is stated as a general macroeconomic geographic theory:

> Going even further, one might conceive of the General Equilibrium Price Theory restated in potentials in which all commodity and factor prices are mutually interrelated and simultaneously determining and determined . . . in a space–time continuum.[10]

The potential model, the instrument which mutually interrelates, simultaneously determines and is determined, is obviously the *deus ex machina* with which we are basically concerned. Only through it were the conclusions of this study arrived at, and only through it can an explanation of the conclusions of this study be offered. The potential model (as explained in detail in the next section) aggregates linear distances and mass points into a functional whole, i.e., it *abstracts* discrete observations into a mathematical continuum. The descriptive unit is no longer *part* but *whole*. Being whole it no longer comprehends limited variables but only universals. It offers no explanation of areally limited variables.

It should now be clear that Warntz cannot be brought to account for not getting better estimates of the observed data than he does, in that he has carefully reduced to zero all "specifically limited variables," such as climate, soil fertility, and cultural variations, which might account for "differences among parts of the country" which might, in turn, bring his correlations up. Similarly, he has accepted his three universals—time, distance, mass — as given (i.e., with an exponent of one) rather than weighting them, which would admittedly give a "better fit." How then is his thesis to be tested if one is not allowed to judge by the predictions of the model used which by prearrangement are not "to analyze the individual peculiarities of the commodities involved"?

> . . . it is the purpose rather to show that a significantly high R can be obtained by recourse to the dimensional analysis set forth in this study and to substantiate the hypotheses concerning the universal effects of the potentials used to express dimensional relationships, thereby furnishing concepts and tools for particular and individual analyses that may be undertaken.[11]

If this statement is taken literally it precludes any testing of the hypothesis by the observed data. That is, any model that can make a better prediction than the Warntz potential model can be disallowed on the basis that it does not incorporate, or incorporates more than, the a priori universals of his Newtonian paradigm, viz.:

> Special care must be taken to *ensure the observance of the macroscopic point of view*. Those who insist that no laws of geographical distribution are possible and then offer microscopic observations in support of their position have avoided the issue. In social science as in physical science, the behavior

[9] *Ibid.*, pp. 100, 104. "Well, it was found that the price of a commodity does indeed tend to vary geographically with the concomitant geographical variation in the intensity of supply and demand."

[10] *Ibid.*, p. 104.

[11] *Ibid.*, p. 90.

> of the individual may not be considered as determined, but in both sciences aggregate behavior viewed macroscopically is determined and generalizations about it can be made, *once the proper dimensions are isolated and recognized.*[12]

The above quotations if taken as necessary presuppositions refer any discussion or criticism merely to the assumptions of the model rather than to an empirical testing of its predictive power. This, it seems, was the intent.[13]

The assumptions underlying the potential model pose two immediate questions. In the first instance, why must economic phenomena which are areally limited on the earth's surface be analyzed as a continuum—a whole or *gestalt*—the parameters of which are areally not bounded? Secondly, and inferentially, why do *all other* macroscopic (or aggregate) studies of areal differentiation of economic phenomena areally limit their wholes or *gestalts* and employ variables or exponents areally bounded? The second question will be taken up first inasmuch as it makes the first question of only rhetorical interest.

II

The Gravity Model[14]

Although the earliest formulation of the gravity model for human activity has been credited to Henry C. Carey in the 1850's, relatively little, aside from the migration studies of Ravenstein, was done with the gravity concept until the 1920's and early 1930's when W. J. Reilly and J. H. S. Bossard applied the idea to the analysis of retail trade areas and marriage selection in urban areas.[15] George K. Zipf probably did more than any other individual to bring the gravity model of human interaction, or, as it is sometimes called, the interactance hypothesis, to the attention of economists, sociologists, geographers, and city planners. He published, during the decade of the 1940's, a number of studies in which the gravity concept was applied to the analysis of such items as inter-city telephone calls and bus passenger traffic, the circulation of newspapers, and the residences of individuals reported in the obituary columns of the New York *Times*.[16] Contemporaneous with these studies were several articles by John Q. Stewart who used the gravity model to analyze the residences of students enrolled in such "national" universities as Harvard, Yale, Princeton, and Massachusetts Institute of Technology.[17]

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[12] Warntz, "Geography at Mid-Twentieth Century," pp. 450, 453–54. The italics are ours.

[13] Warntz, *Toward a Geography of Price*, pp. 90–92. Models with greater predictive power are easily constructed but inasmuch as this is not the point the remainder of the discussion will be largely concerned with the model's descriptive power.

[14] The gravity concept, stated simply, is that the amount of interaction between two population groups varies directly with the size of the populations and inversely with the distance which separates them. A word of caution regarding terminology may be appropriate at this point. To cite a specific case, the geographer is often asked to recall "the *purely physical* nature of population density, a concept now readily accepted by the geographical profession." W. Warntz, "Progress in Economic Geography," p. 64. This analogy presumably makes easier the geographer's acceptance of such ideas as potential, gravity, etc. There is nothing *purely physical* about density, gravity, or potential—these words designate mathematical formulae and concepts (models) which may be used in any science. For example, the notion of population per unit area (density) was clearly established and accepted in the "Politiccal Arithmitik" of the seventeenth century which probably influenced Newton more than he influenced it. A model "borrowed" from physics carries no *physical* meaning in its new use.

[15] H. C. Carey, *Principles of Social Science*, three volumes (Philadelphia: J. B. Lippincott and Co., 1858–1859) Vol. I, pp. 42–43; E. G. Ravenstein, "The Laws of Migration," *Journal of the Royal Statistical Society*, Vol. 48 (June, 1885), pp. 167–227, and Vol. 52 (June, 1889), pp. 241–301; W. J. Reilly, *The Law of Retail Gravitation* (New York: W. J. Reilly Co., 1931); J. H. S. Bossard, "Residential Propinquity as a Factor in Marriage Selection," *American Journal of Sociology*, Vol. 38 (September, 1932), pp. 219–24. E. C. Young, *The Movement of Farm Population*, Bulletin 426, Cornell Agricultural Experiment Station (Ithaca, 1924), is another early formulation of the gravity concept.

[16] *National Unity and Disunity* (Bloomington, Indiana: Principia Press, 1941); "The P_1P_2/D Hypothesis: On the Intercity Movement of Persons," *American Sociological Review*, Vol. 11 (December, 1946), pp. 677–86; "The P_1P_2 Hypothesis: the Case of Railway Express," *Journal of Psychology*, Vol. 22 (July, 1946), pp. 3–8; *Human Behavior and the Principle of Least Effort* (Cambridge, Mass.: Addison-Wesley Press, 1949).

[17] "An Inverse Distance Variation for Certain Social Influences," *Science*, N.S. Vol. 93 (January, 1941), pp. 89–90; "A Measure of the Influence of Population at a Distance," *Sociometry*, Vol. 5 (February, 1942), pp. 63–71. In the earlier of these articles Stewart attempted to relate actual rural densities of population to densities computed on the basis of a potential rather than a gravity model, about which more will be said later.

The last ten years have seen the gravity model applied to a great variety of social data in the fields of marketing, traffic analysis, city planning, prediction of demographic trends, economic geography, etc.[18] Two trends are evident in these recent studies: (1) the hypothesis has been applied increasingly to specific problems at large scales (traffic prediction in large cities, for example); and (2) the model has been assumed to be correct and then used to describe quantitatively the effect of political or linguistic boundaries, or the effects of free competition or monopoly on economic activity. In essence, the model assumes given conditions (i.e., with exponents of unity for the three variables: mass, time, and distance) and the researcher then subjects the residuals to further analysis, particularly through the technique of plotting these residuals on maps.[19]

Weighting the Distance Factor

As stated formally by Stewart "the gravitational energy between two masses varies as the product of the masses divided . . . by the first power of the intervening distance."[20] This statement does not differ substantially from earlier formulations of the gravity model, except that in some models the distance factor has a varying exponent. Yet this difference is critical, for running through all the studies of the past decade has been a debate concerning the philosophical implications of modifying the basic model by assigning different exponent values to population or distance. Some of these arguments should be considered here.

Warntz pleads for the retention of the exponent value of one for space and time, arguing that "space and time are to be recognized not just as cost incurring external frictions, but rather as dimensions of the economic system and hence to be treated isomorphically in the rigid pattern of mathematical physics."[21] More recently Stewart has spoken to the same point: "In any physical situation alteration of the power [i.e., the exponent of one] would be a serious matter, not one merely of the choice of an adjustable parameter. . . . The 'weight' assigned to the people is not similarly critical; it can and must be adjusted to fit the observations."[22]

We have noted that several early studies suggest a varying exponent for distance. The empirical evidence is particularly convincing that different exponents for distance should be assigned to different kinds of interaction in urban areas. Hansen indicates that the exponent decreases with the importance of the trip, from more than two for school trips to less than one for work trips.[23] Carroll found that

[18] A useful review and bibliography of gravity and potential models is presented in Gerald A. P. Carrothers, "An Historical Review of the Gravity and Potential Concepts of Human Interaction," *Journal of the American Institute of Planners*, Vol. 22 (Spring, 1956), pp. 94–102. In each of the five volumes of the *Papers and Proceedings* of the Regional Science Association which have appeared to date (1955–59), there are articles making use of gravity or potential models. Of particular interest are papers in Vols. 2, 4, and 5 by Anderson, Dunn, Carrothers, Isard and Bramhall, and Schneider with the remarks of the discussants of these papers.

[19] Edward J. Taaffe, "A Map Analysis of United States Airline Competition," *Journal of Air Law and Commerce*, Part I "The Development of Competition," Vol. 25 (Spring, 1958), pp. 121–47; Part II "Competition and Growth," Vol. 25 (Autumn, 1958), pp. 402–27; and J. Ross Mackay, "The Interactance Hypothesis and Boundaries in Canada: A Preliminary Study," *The Canadian Geographer*, No. 11 (1958), pp. 1–8. As Taaffe indicates in his recent article, "Trends in Airline Passenger Traffic: A Geographic Case Study," *Annals*, Association of American Geographers, Vol. 49 (December, 1959), p. 402, ". . . the mapping of residuals is regarded as a descriptive device whereby the departure from a weak general relationship may be examined on a map for purposes of suggesting additional relationships."

[20] Stewart, "Concerning 'Social Physics'," *Scientific American*, Vol. 178:5 (May, 1948), p. 21.

[21] Warntz, "Geography of Prices and Spatial Interaction," *Papers and Proceedings*, Regional Science Association, Vol. 3 (1957), p. 128. The argument here is not over the exponential difference between vector/force and scalar/energy quantities.

[22] Stewart, discussion, "Population Projection by Means of Income Potential Models," *Papers and Proceedings*, Regional Science Association, Vol. 4 (1958), p. 153. It should be made clear that "weight" is an exponent. Changing mass from "people" to "college students" or "income" is not weighting. Time, space, and mass are merely dimensions, of course, neither physical nor social as such.

[23] Walter G. Hansen, "How Accessibility Shapes Land Use," *Journal of the American Institute of Planners*, Vol. 25 (May, 1959), pp. 73–76. This article appeared in a special issue of the *Journal of the American Institute of Planners*, edited by Alan M. Voorhees. Gravity models figure importantly in these studies. Particular mention might be made of William B. Calland, "Traffic Forecasting for Freeway Planning," pp. 82–86; John R. Hamburg and Roger L. Creighton, "Predicting Chicago's Land Use Pattern," pp. 67–72; and James Booth and Robert Morris, "Transit vs. Auto Travel in the Future," pp. 90–95.

interurban travel required exponents of from 2.5 to 3.0[24] Nor are these exponents which exceed one necessarily limited to gravity models applied to specific small areas. Taaffe has noted that in "a number of empirical studies of air transportation and commodity movements . . . there seemed to be distance effects only within rather restricted inner zones. Beyond these zones there seemed to be a sort of plateau of interaction as regards distance effects." And he concludes by stating that "although more elaborate formulations of the distance variable might encompass these fundamentally spatial effects, it may well be that a more meaningful frame of reference could be formulated without any explicit reference to distance."[25]

To make matters slightly more complicated, mention should be made of Carrothers' suggestion that "the exponent may be a variable function related inversely to distance itself, rather than to population."[26] That is, there is greater friction to a person's moving one mile in a city than there is to his moving one mile in the country. Carrothers' subsequent work with the income potential model has at least in part substantiated his hypothesis that "the friction against human interaction which is represented by physical distance between persons tends to be higher in more densely developed areas."[27]

In fairness to those who advocate an inflexible adherence to the exponent of one for distance, it must be said that certain ubiquitous sociological phenomena may be best described by a gravity model using one as the exponent of distance. Air travel is a good example of an activity that is *not* engaged in by the entire population. Perhaps in time the exponent for this and other things that are unevenly distributed through the population might decrease gradually toward the value of one. But it seems a long way off—this millenium in which everything is evenly distributed through populations; and were such a thing to happen, it is not likely that there would remain any differences from place to place to engage the attention of geographers.

Modifying the Population Factor

There has been no sharp disagreement on the validity of varying the data which represent mass in the gravity model. Stewart recognized at the outset the necessity of some sort of modification, although his weighting was applied in a highly arbitrary manner to select geographical portions of the United States—nine southern states and eleven western states. Dodd found that "differentials of sex, age, income, education, occupation, marital status, political, religious and other affiliations," may have considerable bearing on the capacity for social interaction of an individual.[28] In most of the recently published work on potential and gravity models, the mass, numbers of people, has been changed to age, income, etc. Carrothers even takes the position that populations of different sizes should be raised to variable powers greater than one, since "a larger population in one area than another may of itself result in an influence for the first area larger proportionately than can

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These articles apply the gravity concept in varying ways to Washington, D.C., San Diego, Chicago, and Baltimore and generally stress the necessity of using some function of distance, relating it to particular kinds of trips and modes of transportation.

[24] J. Douglas Carroll, Jr., "Spatial Interaction and the Urban–Metropolitan Regional Description," *Papers and Proceedings*, Regional Science Association, Vol. 1 (1955), pp. D1–14; J. D. Carroll, Jr., "Defining Urban Trade Areas," *Traffic Quarterly*, Vol. 9: 2 (April, 1955), pp. 149–61; and in a re-examination of Reilly's *Law of Retail Gravitation*, P. D. Converse, "New Laws of Retail Gravitation," *Journal of Marketing*, Vol. 14 (November, 1949), p. 383, found that exponents exceeding two are necessary to account for the trade attraction of small towns in the vicinity of Chicago.

[25] E. J. Taaffe, discussion, "Regional Employment and Population Forecasts via Relative Income Potential Models," *Papers and Proceedings*, Regional Science Association, Vol. 5 (1959), p. 49. See contributory evidence in Carl Hammer and Fred C. Iklé, "Intercity Telephone and Airline Traffic Related to Distance and the Propensity to Interact," *Sociometry*, Vol. 20 (December, 1957), pp. 306–16; and Benjamin Chinitz, "The Effect of Transportation Form on Regional Economic Growth," *Traffic Quarterly*, Vol. 14: 2 (April, 1960), pp. 129–42.

[26] "An Historical Review of the Gravity and Potential Concepts of Human Interaction," p. 97.

[27] G. A. P. Carrothers, "Population Projection by Means of Income Potential Models," *Papers and Proceedings*, Regional Science Association, Vol. 4 (1958), p. 149.

[28] Stuart C. Dodd, "The Interactance Hypothesis: A Gravity Model Fitting Physical Masses and Human Groups," *American Sociological Review*, Vol. 15 (April, 1950), p. 246. See also Joseph A. Cavanaugh, "Formulation, Analysis and Testing of the Interactance Hypothesis," *American Sociological Review*, Vol. 15 (December, 1950), pp. 763–66.

be accounted for by the modification of population size by a single multiplier."[29]

An interesting outgrowth of the gravity model is Stouffer's concept of "Intervening Opportunities," which has had a development separate but contemporaneous with much recent work with gravity and potential models.[30] His model, which is designed to account for the movement of population, states that "the number of people going a given distance(s) from a point is not a function of the distance directly but rather a function of the spatial distribution of opportunities."[31] His analyses have already contributed to "migration theory by demonstrating the shortcomings of a mere mechanical use of physical distance and by demonstrating rather dramatically the advantages of a better model in the reduction *both* of average and systematic error."[32] Since this model seeks to describe some of the same regularities studied by means of gravity and potential approaches, future studies using the concept will be worth noting.

The Potential Model

The earliest example of the use of a potential model came almost as an afterthought in an article by J. Q. Stewart in *Science* in 1941, the main portion of which was devoted to showing that the inverse distance variation could account for the geographical residences of Princeton undergraduates.[33] The latter half of the article is an attempt to relate actual rural densities of population to densities computed on the basis of equipotential values. The populations and distances of the forty-eight states form the universe, but only the thirty-seven states which are east of Colorado are analyzed. For these Stewart finds that the actual rural densities for states in the Deep South run about one and one-half the computed densities. "This systematic deviation is due to the concentration there of the Negro population."[34]

In 1945 maps of population potential for the United States and Europe appeared for the first time in Stewart's *Coasts, Waves, and Weather*. The map of Europe, prepared by Dudley Kirk, was used the following year in that author's book, *Europe's Population in the Interwar Years*. In both books the maps were used only for general illustrative purposes.[35] A year later, however, Stewart explored the problem of discovering empirical regularities in the distribution and equilibrium of population in an article which appeared in the *Geographical Review*.[36] He analyzed four kinds of regularity which he observed in the distri-

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[29] "An Historical Review of the Gravity and Potential Concepts of Human Interaction," p. 98.

[30] Samuel A. Stouffer, "Intervening Opportunities: A Theory Relating Mobility and Distance," *American Sociological Review*, Vol. 5 (December, 1940), pp. 845–67; Theodore R. Anderson, "Intermetropolitan Migration: A Comparison of the Hypotheses of Zipf and Stouffer," *American Sociological Review*, Vol. 20 (June, 1955), pp. 287–91 (a good bibliography is included); also "Comment" by F. C. Iklé and "Reply," same volume, pp. 713–15; Edward L. Ullman, *American Commodity Flow: A Geographical Interpretation of Rail and Water Traffic Based on Principles of Spatial Interchange* (Seattle: University of Washington Press, 1957); and S. A. Stouffer, "Intervening Opportunities and Competing Migrants," *Journal of Regional Science*, Vol. 2 (Spring, 1960), pp. 1–26.

[31] Stouffer, "Intervening Opportunities and Competing Migrants," p. 1.

[32] *Ibid.*, p. 18. Charles T. Stewart, Jr., "Migration as a Function of Population and Distance," *American Sociological Review*, Vol. 25 (April, 1960), pp. 347–56, comments that "tests of Stouffer's hypothesis for the United States and Sweden have been described as 'encouraging' but have not been clearly confirming" (p. 348). His general conclusions are also pertinent: "Net migration is not simply related to population and distance" (p. 347), and "limited empirical data do not support the hypothesis that migration is proportional to the population of the city of destination, nor that it is inversely proportional to the distance of migration" (p. 356). Of direct interest is Hägerstrand's study in David Hannerberg, Torsten Hägerstrand and Bruno Odeving, eds., *Migration in Sweden: A Symposium* (Lund Studies in Geography, Ser. B. Human Geography No. 13 [Lund, 1957]), pp. 27–158 (especially Part IV).

[33] J. Q. Stewart, "An Inverse Distance Variation for Certain Social Influences," pp. 89–90. One of the principal points made in the article is that Princeton University is a national rather than a sectional school in refutation of an assertion made by C. R. Foster and P. S. Dwyer in "A Study of the Geographical Distribution of Students," *Rutgers University Bulletin* (July, 1931), Series VII, No. 1. Stewart concludes that "the classification by Foster and Dwyer of Princeton as 'sectional' is definitely unjustified in the light of the more refined statistics here developed" (p. 70).

[34] J. Q. Stewart, "An Inverse Distance Variation for Certain Social Influences," p. 90.

[35] J. Q. Stewart, *Coasts, Waves, and Weather* (New York: Ginn and Company, 1945), maps on pp. 164 and 166; Dudley Kirk, *Europe's Population in the Interwar Years* (League of Nations, 1946), map on p. 9.

[36] "Empirical Mathematical Rules Concerning the Distribution and Equilibrium of Population," *Geographical Review*, Vol. 37 (July, 1947), pp. 461–85.

bution of people. The first regularity is concerned with the rank–size rule which Zipf, A. J. Lotka, Colin Clark, Christaller, Lösch, and Martin J. Beckmann have investigated.[37] The remaining three rules are derivatives of the potential of population. They are: (1) the rule concerning the relation of the number of United States cities and the urban fraction; (2) the rural density rule, which expresses an equilibrium between rural population and total population; and (3) the equation for the potential of population.

In formulating population potential, Stewart assumed that a group of people exerts at any point an "influence" that varies directly with the size of the population and inversely with the distance from the point. In this context Warntz has come to use the terms "accessibility" and "influence" interchangeably. The potential at any point is found by summing the values one obtains by moving each member of the population to that point and dividing each movement by the distance traversed. Thus aggregates of accessibility/influence may be found for any point, and equipotential lines connecting points of equal potential can be drawn representing a statistical "surface." From this surface the potential value at any point may be read. Since the constructed surface is a continuous "field" quantity, it may be compared with other continuous surfaces in the manner explained by Robinson and Bryson.[38]

A great variety of sociological data has since been studied by means of the potential model. The first thorough attempt at documentation was presented by Stewart in 1948, seven years after the appearance of the potential model in *Science*.[39] In this article, such items as rural population density, rural nonfarm rent, farm value, railroad mileage per square mile, miles of rural free delivery routes per square mile, manufacturing wage earners per square mile, death rate, and per capita income were plotted against the potential values applicable at the centers of states. The data were not mapped but they were shown on scatter diagrams with approximated regression lines fitted to them. A disquieting feature of the article is that the analysis of the fit between the model and the observations was confined to the twenty-eight states east of Colorado and north of the nine southern states. With one exception the scatter diagrams showed the data for the twenty-eight states, or for 253 counties from within these states, which were specially selected and statistically smoothed in groups of eleven. In the case of the one exception, the data for the nine southern and eleven western states were weighted by exponents of 0.8 and 2.0, respectively.

This certainly accords ill with the basic tenet that "no part of a true system can be thoroughly understood without reference to the whole."[40] If a model takes all of the

[37] The rank–size rule is presumably an expression of the equilibrium that results from urban competition, and although a distant cousin to the gravity concept, is not of immediate concern here. See the review and analysis given by Charles T. Stewart, Jr., in "The Size and Spacing of Cities," *Geographical Review*, Vol. 48 (April, 1958), pp. 222–45; also Walter Isard, *Location and Space Economy* (New York: John Wiley & Sons, 1956), pp. 55–76; and Rutledge Vining, "A Description of Certain Spatial Aspects of an Economic System," *Economic Development and Cultural Change*, Vol. 3 (January, 1955), pp. 147–95. Martin J. Beckmann, "City Hierarchies and the Distribution of City Size," *Economic Development and Cultural Change*, Vol. 6 (April, 1958), pp. 243–48 is technical. C. T. Stewart should be compared with Brian J. L. Berry and William L. Garrison, "Alternate Explanations of Urban Rank–Size Relationships," *Annals*, Association of American Geographers, Vol. 48 (March, 1958), pp. 83–91.

[38] Arthur H. Robinson and Reid A. Bryson, "A Method for Describing Quantitatively the Correspondence of Geographical Distributions," *Annals*, Association of American Geographers, Vol. 47 (December, 1957), pp. 379–91. It is, of course, true as Robinson and Bryson have noted, that in dealing with discrete data generalized into a continuous surface, the isoline pattern may be readily modified by changing the set of distributors (e.g., by using minor civil divisions rather than counties from which to compute densities of people per square mile). Nonetheless, the technique is admirably suited to the comparison of two statistical surfaces, especially so for the potential model whose surface is continuous.

[39] J. Q. Stewart, "Demographic Gravitation: Evidence and Applications," *Sociometry*, Vol. 11 (February–May, 1948), pp. 31–58. Two interesting summaries by Stewart of the historical development of social physics and the agenda for the "social engineering" to come (each written for a different reading public) are to be found in "The Development of Social Physics," *American Journal of Physics*, Vol. 18 (May, 1950), pp. 239–53, and "A Basis for Social Physics," *Impact of Science on Society*, Vol. 3 (Summer, 1952), pp. 110–33.

[40] Stewart and Warntz, "Macrogeography and Social Science," p. 168; also Warntz, "Geography at Mid-Twentieth Century," p. 449.

United States as its "true system" then the consequences of the hypothesis on which the model is based must be carried out for all areas without changing the data for selected states. One does not explain a true system by leaving out part of it, nor does one explain a true system by weighting the data of its deviate parts.

The decade of the 1950's added many examples of the use of potential models in geographic analysis.[41] We need not argue the matter of exponents for distance or mass since the points which were advanced for the gravity model apply also to the potential model. It will suffice to note that Chauncy Harris in his study of the market as a factor in the localization of industry used transport cost, which he considered to be a superior measure of distance to sheer mileage.[42] A similar view is held by Philip Herr in a recent article in *Urban Land* in which he uses the potential model to analyze the pattern of transport costs and the effects of highway location on this pattern:

> To measure the effects of the transportation system, some of the unrealistic assumptions of these models are dropped. Rather than unchanneled transportation, the actual configuration of transport lines is used. Rather than costs exactly and uniformly proportional to distance, rates varying with mode, distance, and quality of facility are used, measuring both dollar cost and elapsed time, which is given an imputed fiscal value.[43]

Herr makes a clear distinction between the accessibility model and the potential model, which assumes straight-line distances and costs:

> The terms "potential" and "accessibility" have frequently been used interchangeably. In this study, "potential" refers to the set of values obtained using spatial separation as the "distance" dimension; "accessibility" refers to the set of values obtained using time and cost separation over the actual system configuration.[44]

Exponent values for mass, time, and distance are doubtless matters of considerable concern to the user of gravity and potential models, but this is quite likely an argument which cannot be resolved. It would seem that the more specific the data (whether highly localized geographically or restricted to a narrow stratum of society) the less probable it is that an exponent of one for distance will give a good description of its spatial occurrence or interaction. Perhaps this is properly a domestic matter for the model users themselves to decide. There are, however, a number of questions we would like to explore regarding the uses to which the potential model may be put in geographical research, and the insights we should expect to gain from its use.

III

The reviews of the development and use of the interactance, gravity, and early Stewart potential models all point to one singular fact: there is in reality no areally unbounded continuum or functional whole. That is, neither time, distance, nor mass can be taken as given conditions for an unlimited area in the predic-

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[41] Reavis Cox and Wroe Alderson, *Theory in Marketing* (Chicago: Richard D. Irwin, Inc., 1950), Chap. 2, "Potential of Population and Its Relationship to Marketing," pp. 19–40 by J. Q. Stewart; Chauncy Harris, "The Market as a Factor in the Localization of Industry in the United States," *Annals*, Association of American Geographers, Vol. 44 (December, 1954), pp. 315–48 (a useful bibliography, particularly on the matter of exponents, is contained in the footnotes of this article); W. Warntz, "Measuring Spatial Association with Special Consideration of the Case of Market Orientation of Production," *Journal of the American Statistical Association*, Vol. 51 (December, 1956), pp. 597–604; J. Q. Stewart and W. Warntz, "Physics of Population Distribution," *Journal of Regional Science*, Vol. 1 (Summer, 1958), pp. 99–123; W. Warntz and David Neft, "Contributions to a Statistical Methodology for Areal Distributions," *Journal of Regional Science*, Vol. 2 (Spring, 1960), pp. 47–66; and Philip B. Herr, "The Regional Impact of Highways," *Urban Land*, Vol. 19 (February, 1960), pp. 3–8. Also previous citations in footnotes 1, 6, 18, 21, 22, 25 and 27.

[42] Harris, *op. cit.*, p. 322. In potential continuum studies carried out by Reino Ajo in Sweden and Finland, which are closest in example to the Stewart/Warntz methods, the point is made that closer predictive fits would result if "exceptional transportation conditions could be taken into account in terms of distance by measuring the effective distance in terms of transport resistance instead of the usual physical length." Reino Ajo, *An Analysis of Automobile Frequencies in a Human Geographic Continuum* (Lund Studies in Geography, Ser. B. Human Geography No. 15 [Lund, 1955]), p. 13. See also R. Ajo, *Contributions to "Social Physics"* (Lund Studies in Geography, Ser. B. Human Geography No. 11 [Lund, 1953]).

[43] Herr, *op. cit.*, p. 4.

[44] *Ibid.*, p. 4. The equation "population potential equals aggregate accessibility of people to a place" is a consistent Warntz assumption inference. See W. Warntz, "A Methodological Consideration of Some Geographic Aspects of the Newfoundland Referendum on Confederation with Canada, 1948," *The Canadian Geographer*, No. 6 (1955), pp. 39–49.

tion or explanation of the areal differentiation of observed human behavior on the earth's surface. In every study, other than those using the Stewart/Warntz model, it has been found expedient to weight (i.e., correct) the "universal" dimensions of time, distance, and/or mass by some empirically derived exponent. Further, no models, other than the Stewart/Warntz postulations, are credited with having unbounded areal application. These differences between the areally limited interactance–gravity models and the potential–continuum models are fundamental differences of kind rather than of degree. The purpose of model construction is heuristic in the study of empirical data. The test of a model is in its applicability. In this instance the burden of proof for heuristic value rests heavily on the potential model — but heuristic value as to prediction and explanation of particular areal occurrence is not the point of potential studies as previously noted. What then is the point?

Potential models have three variables, that is, there are three "causes" (mass, time, and distance). The three variables are taken as given; they are predetermined. The three variables are functionally related, i.e., they are mutually and simultaneously determining. Thus, there is a causal nexus, but there is no possible isolation or determination of cause and effect.[45] There is no analysis of process; there can be no explanation. Is there prediction?

Potential models do predict. However, they predict *tendencies* toward a spatial equilibrium, not areal occurrence. That is, they measure mutual relations between the patterns of abstracted (extended) phenomena. What is predicted then is an integrated value which can be compared only with other like integrated values.[46] The "contours" of the potential maps have no specific denotation. They are statistical "surfaces" which have no reference to event/places on the earth's surface represented by the *map* on which the potentials are contoured. There is no direct correspondence, therefore, between the empirical surface of discrete observation and the statistical surface of potential calculi (or rather there should not be).[47] What meaning has this for geography?

As pointed out previously, the most significant meaning is that potential model studies have no *place*. They do not apply to the particulars of *locality*. They do not *areally* differentiate in any *geo*-graphic sense.[48] The

[45] "Here cause and effect fade and the mutual relations of general patterns are stressed. The macroscopic equations relate only to the tendencies toward spatial equilibrium as it exists at a given time . . . ," Warntz, "Geography at Mid-Twentieth Century," p. 454. The problem of what is cause and what is effect is characteristic of all equilibrium, functional studies and is mathematically insoluble: "Actually the spatial factor is probably a result rather than a 'cause' operating in marital choice," Alfred C. Clarke, "An Examination of the Operation of Residential Propinquity as a Factor in Mate Selection," *American Sociological Review*, Vol. 17 (February, 1952), p. 22.

[46] (By analogy to gas laws) "The interrelations of the macroscopic phenomena in the continuum are predictable even though the behavior of no individual molecule is, save for certain probability statements." Warntz, *ibid.*, p. 449. Probability statements, of course, apply to no individual but only to all members of a class.

[47] It is hard to judge what purpose the maps of potential studies serve other than illustration. A map is a discrete discontinuous distribution; the potential surface is an abstracted continuous distribution. Correspondence is illusory. Insights gained from such comparison are correspondingly illusory. "Explanations" like the following are a case in point: "Across northern New Hampshire, the contour of 90,000 miles was lowered relatively little, to 70,000, by Southern opposition, and we recall that the carriage road up Mt. Washington was constructed during the Civil War, though surely it was a 'nonessential' enterprise! In this area, though many men enlisted, at home it seems to have been 'business as usual'." Stewart and Warntz, "Macrogeography and Social Science," p. 181. (In point of fact, the statement regarding the carriage road is simply not true. The carriage road, begun in 1853, was essentially completed before the Civil War began. Its official dedication on August 8, 1861, places its completion only two and one-half weeks after the first real engagement of the war, the First Battle of Bull Run.)

[48] "There exists a measurable factor. . . . Not residing or measurable in one individual, it is nevertheless the result of the combined *influence* of all—which influence necessarily varies from place to place, i.e. geographically." Warntz, "Geography at Mid-Twentieth Century," p. 450. It seems perfectly clear from this statement that the potential value has place only in reference to the grid of the continuum, not to place in a geographical sense. If value varies from place to place on the earth's surface it does reside and is measurable in some phenomenon. It is granted that there are point values on the potential surface, but they *cannot* be "dropped down" for comparison with other statistical or empirical surfaces of a different level of abstraction and integration, for there is always a problem of scale involved insofar as one surface is composed of relative values computed

potential surface is a mathematical continuum integrating *all* mass (all phenomena of a single class) in time/space. By definition, the contoured surface cannot end — it blankets the earth. If people are "mass" they all have the same value — *everywhere*. If income is "mass," *all* incomes must be integrated. If onions are "mass," all onions, everywhere, are mutually interrelated, simultaneously determining and determined. If, for the sake of convenience, all discrete masses cannot be individually integrated, control points should be uniformly spaced throughout the continuum. There is no logical reason for selecting as control points centers of states or major population centers or any other *particular* (i.e., representative geographic) place. In short, the *whole* is a continuum and unbounded.

This problem, the definition of the whole, is the central problem in all macroscopic models and functional analyses. Inasmuch as the phenomenal variable is assumed by these models to be in reciprocal relation in a functional system, some definition of the extent of the system must be made. In the potential model the assumption of a time/space continuum leaves the extent of the system unbounded.[49] There is, therefore, no logical defense for a potential study of a region or part of a region, based on a universe composed of only that area unless some evidence is given of a limiting functional boundary to that universe, i.e., that the population has no pertinent relations outside the area and all pertinent relations inside the area are reciprocal. If the mass is wheat, all wheat in competitive relationship must be accounted for and any wheat not competitive must be excluded. And so on, *mutatis mutandis*.

On the other hand, interactance–gravity models can be used to define functional systems, wholes or boundaries, as illustrated in the review above. The potential model, taking its variables as given in a time/space continuum, serves no such purpose except negatively.[50] The widespread use of exponents is evidence par excellence of the absence of a time/space continuum in any unbounded sense. Functional wholes of any large areal extent or any large number of variables are exceedingly rare, and even though known to exist, their extension in area and duration in time is basically conjecture. To decide by a priori fiat that distance and mass are as given and that an unbounded time/space continuum exists in economic terms in the face of overwhelming evidence to the contrary, virtually eliminates the application of these models in empirical studies.

What then is the meaning for geography of the potential model? The definition of geography, as given in these studies, is of the following character:

> The study of geography is concerned with the areal differentiation of phenomena. The objective of geography is to describe geographical patterns and

from arbitrary statistical units. Unfortunately potential studies have just such incongruities, e.g., comparison of potential surfaces with rural farm population, wage earners, road densities, and death rate (not to mention singular historical events). On the problem of scale see Warntz, "Contributions Toward a Macroeconomic Geography," p. 423; and Warntz, "Measuring Spatial Association with Special Consideration of the Case of Market Orientation of Production," pp. 598, 602–3.

[49] Warntz, "Progress in Economic Geography," p. 58: "The concept of a system is necessary. If this be thought of as a geographic system, that is, 'space-occupying,' then the application of 'fields' is necessary." Warntz, *Toward a Geography of Price*, p. 30: "For the purposes of social science it may be useful to assume that any concentration of population exerts an influence varying directly with the size of the population. It is logical to assume that this influence is diminished by distance. This influence exists throughout the area occupied by the population and beyond this area, losing in intensity as distance increases. There exists, then, a field of force around a population cluster and at any point in the field the intensity can be calculated by dividing the size of the population by the distance involved."

[50] A negative example is the Stewart/Warntz model indicating values of 1, 0.8, and 2 as the molecular weight of people in the East, South, and West, respectively. Stewart and Warntz, "Macrogeography and Social Science," p. 169. In direct reference to given variables, it has been pointed out that "the effect of distance cannot be determined without empirical research," and that "simplifying assumptions . . . disregard the deposit of previous interactions and give no rationale to make the suggested function of distance more plausible." F. C. Iklé, "Sociological Relationship of Traffic to Population and Distance," *Traffic Quarterly*, Vol. 8: 2 (April, 1954), pp. 126–27. Dunn has used a limited potential model to picture general market structure (area) and analyze the location problems of a particular firm. His remarks on shifts of pattern over time and the use of exponents are particularly pertinent. Edgar S. Dunn, "The Market Potential Concept and the Analysis of Location," *Papers and Proceedings*, Regional Science Association, Vol. 2 (1956), pp. 183–94.

to discover the causes and consequences of given areal distributions.[51]

Macrogeography as exemplified by potential studies would seek to accomplish these objectives by studying the spatial aspects of the economic system as aggregate distributions expressed "in the mapping of the spatially continuous variables resulting from the geographical distribution of 'populations' considered as systems of integrated functional wholes."[52] Leaving aside the fact that *causes* are given and not discovered in the potential model, and that discontinuous areal distributions are abstracted into continuous distributions whose *consequences* are mutually set in the model and not individually accounted for, we may turn to the *description* of geographical pattern and areal differentiation. The pattern, or statistical surface, of the model is non-geographical in the sense of not being tied to particular earth surface phenomena. The concept of position under such circumstances is not geographical but related to the manifold of the continuum. Areal differentiation is present but not referent to the discontinuous areal patterns of the earth's surface. In what sense *geographical* place, position, and area are discovered, described, related, or explained is difficult to see. Some insights into, and some understandings of the significance of local variations in microscopic studies have been claimed for macrogeography, but most conclusions have been of a highly generalized nature, e.g., "the price of a commodity does indeed tend to vary geographically with the concomitant geographical variation in the intensity of supply and demand."[53]

It is obvious that potential studies must deal exclusively with tendencies toward a spatial equilibrium and only in this sense are they deterministic, i.e., show cause and consequence. It is the metaphysic of the mechanistic balance wheel of nature that is being proved here. This implicit and explicit teleology of the equilibrium and functional concepts is the essence of the potential model. Insofar as geography's main concern is in the forging of a theory of human society, in establishing one social science, in showing that social and physical science are but mutually related isomorphic examples of one generalized logic—insofar as this is true, there is certainly no better way of accomplishing it than through the potential model. Correspondingly, if this is the high level of abstraction geography is searching for—the seventeenth century lies dead ahead.

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[51] Warntz, *Toward a Geography of Price*, pp. 41–42.

[52] Warntz, "Progress in Economic Geography," p. 59; also Warntz, "Contributions Toward a Macroeconomic Geography," p. 425; Warntz, *Toward a Geography of Price*, pp. 29, 35.

[53] Warntz, *Toward a Geography of Price*, p. 104. Statements to the effect that macroscopic studies "provide a means for understanding the significance of local variations revealed in the microscopic analyses" (Warntz, "Geography at Mid-Twentieth Century," p. 448, and Warntz, "Progress in Economic Geography," p. 58) are, when examined, seen to be of the order that deviations between actual values and potentially estimated values "'agree' with what geographers 'know' about the microgeography of the areas involved." (*Ibid.*, p. 74).

HUGH HAMMOND BENNETT, 1881–1960

CARLETON P. BARNES

United States Department of Agriculture

ONE of the few social goals on which we unite in agreement is soil conservation. Public activities aimed at this goal are enthusiastically supported, never decried, seldom damned with faint praise. This unusual degree of public acceptance of a community activity must be attributed in considerable part to the tireless and persuasive effort of a dynamic man—Hugh H. Bennett. Bennett's long career in the service of mankind ended last July 9, in Burlington, North Carolina.

The United States, and especially southeastern United States, is one of those parts of the world where storms of high intensity combined with row-crop farming produced spectacular gullies, muddy streams, and a relentless loss of surface soil from sloping fields. Hugh Bennett had this combination of circumstances repeatedly forced on his attention when, as a soil surveyor for the then Bureau of Soils, he mapped eroded and gullied soils all over our far-flung corn, cotton, and tobacco regions. He decided that this erosion was destroying the resource base for posterity, that it was not something we had to accept, and that something ought to be done about it.

In *Soil Erosion, a National Menace* (1928), written in collaboration with W. R. Chapline of the Forest Service, he tried to bring the problem to people's attention. But, this was a government bulletin and Bennett knew that few people read government bulletins. Something of a crusade would be needed to excite people to the point where action would be taken. So with speeches and with pictures, he began with his effective brand of earthy eloquence to carry his story to whoever would listen. He realized the dramatic qualities of a gully. Sheet erosion might be the more insidious, but pictures of the road-swallowing, field-slashing gully were what could persuade people that here was a problem of real national concern.

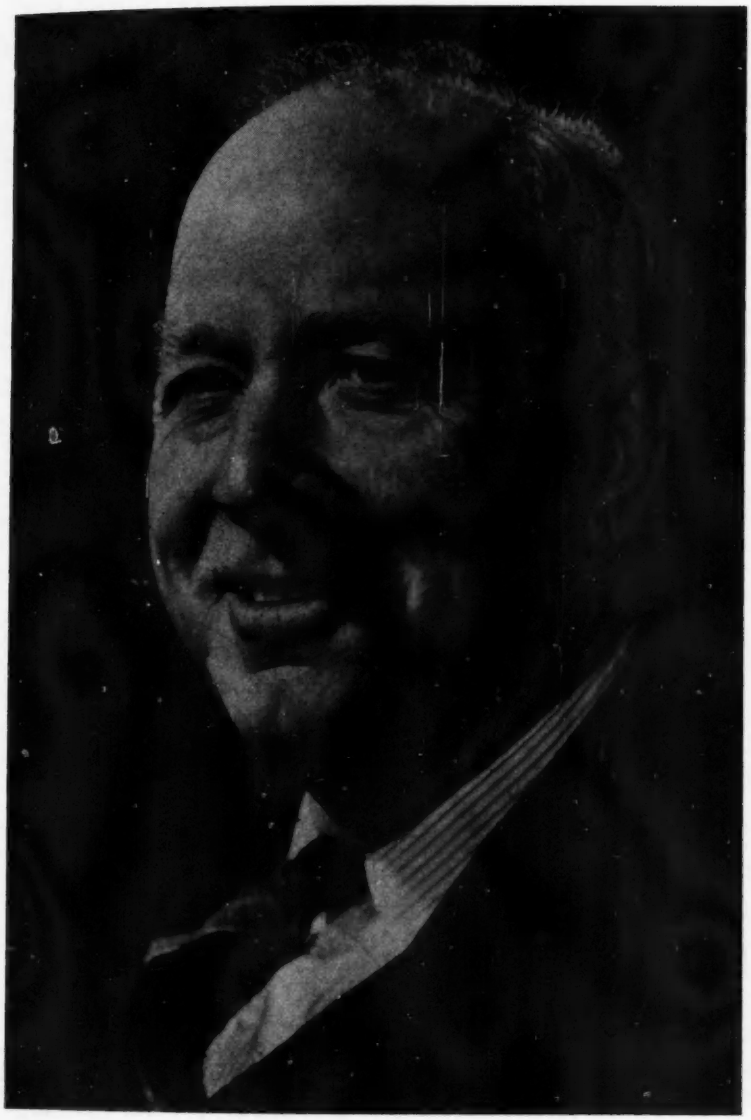
His efforts began to have effect, first in the inauguration of a number of erosion experiment stations, and then, during the early New Deal, in establishment of the Soil Erosion Service, under his leadership, in the Department of the Interior. Presently this agency was transferred to the Department of Agriculture and renamed Soil Conservation Service, of which he continued as chief until his retirement in 1952.

As a soil surveyor in this and other countries, Bennett saw the great complexity in geographic pattern of the soils of any one place, and the enormous diversity of soils, including their surface configuration, from place to place. He was therefore quick to avoid the "one-shot" kind of remedy we so often try to apply to problems in disregard of geographic differences. He insisted that to apply conservation measures intelligently the soils and slopes of a farm must be mapped in enough detail so the field layout, water control, and cropping systems could be designed to fit the circumstances. He also saw that soil conservation was a complex of problems, even on one farm, calling for a systematic application of related measures under a definite plan of establishment which would require teams of technical advisors of different disciplines, not just agronomists or engineers, to assist farmers in their development and application.

Bennett's help was sought and freely given to many countries faced with soil and water conservation problems, both before and after his retirement as head of the Soil Conservation Service. His influence in helping stem the loss of soil resources was world-wide and his service to mankind incalculable.

His public service in the interest of conservation was not limited to the soil. In recent years, while a resident of Fairfax County, Virginia, and a member of the Park Commission, he was instrumental in saving through public acquisition recreational areas at Great Falls needed by the county's burgeoning population.

Hugh Bennett was buried in Arlington National Cemetery, a fighter who served his country no less than those who battled men.



HUGH HAMMOND BENNETT

With the distribution of the present issue of the *Annals* my second and last term as Editor of this publication expires. This service will now be rendered by Dr. Robert S. Platt, Department of Geography, University of Chicago, Chicago 37, Illinois. All manuscripts submitted for *Annals* consideration, other than Review Articles and special maps prepared for the Map Supplement, should be mailed to Dr. Platt.

WALTER M. KOLLMORGEN
Editor